THEATRES

Their Safety from Fire and Panic
Their Comfort and Healthfulness

William Paul Gerhard, C.E.

Gerhard

SX

THEATRES

Their Safety from Fire and Panic, Their Comfort and Healthfulness

THEATRES

Their Safety from Fire and Panic, Their Comfort and Healthfulness

BY

WILLIAM PAUL GERHARD, C. E.

Consulting Engineer for Sanitary Works
Member of the American Public Health Association
Corresponding Member of the American Institute of Architects
Honorary Corresponding Member of the British Fire Prevention Committee
Author of "Prevention of Fire," "Theatre Fires and Panics: Their Causes and Prevention," Etc., Etc.

BOSTON, MASS.
BATES & GUILD COMPANY
1900

PRINTED AT
THE EVERETT PRESS
BOSTON

PREFACE.

THE question of safety in the theatre is one of paramount importance, and though the subject has been often discussed, there are good reasons why it seems well to bring it up from time to time. Next to the question of safety from fire and panic, the comfort and healthfulness of theatre buildings require more attention than is usually bestowed upon them.

The matter forming the first part of this book was first contributed by the author, by request, to the publications of the British Fire Prevention Committee; a condensed abstract of the second part was written originally for *Appleton's Popular Science Monthly*.

The object of the book is to put the matter into more permanent form, and to thus render the same accessible to a larger class of readers.

THE AUTHOR.

36 UNION SQUARE, New York.
March, 1900.

CONTENTS.

THEATRES:

THEIR SAFETY FROM FIRE AND PANIC, THEIR COMFORT AND HEALTHFULNESS.

I.

SAFETY FROM FIRE AND PANIC.*

Man pfercht das Brennlichste zusammen,
Da steht's dann alsobald in Flammen.
Wolfgang von Goethe, Xenien.

IN the following, I will discuss briefly the question of personal safety in theatres. I am well aware of the fact that the ground has been gone over so thoroughly by competent writers as to leave hardly a possibility of making any new or promising suggestions, yet I hold that some good must come from agitating the question over and over again. It is a matter of common observation that when a serious fire disaster has occurred — whether in a hotel, an asylum, a dwelling, or a theatre — the

* This essay was originally prepared as a paper for the Publications of the British Fire Prevention Committee in London. The editor of the publications, Mr. Edwin O. Sachs, wrote the following comments upon the paper, which I quote from the preface to the English edition: —

" . . . The paper which the Executive presents in this publication must rank among the most important so far issued, for not only is the subject deserving of very serious consideration, but the very name of the author commands the full attention of all concerned in fire prevention throughout the world. Mr. Wm. Paul Gerhard is the leading authority

press for a while takes up the subject and discusses means and remedies, while the thoroughly alarmed and frightened public stays away from those theatres or hotels the reputation of which from a safety point of view is doubtful. It is, unfortunately, the rule, however, that as soon as the first excitement subsides, the general interest ceases, and after a very short interval things begin to go again the same way as before, and safety measures or precautions against the well-known dangers to life and limb in such structures are either neglected or forgotten.

In this question history truly repeats itself, and to quote but a few instances, let me recall the numerous suggestions for theatre reform, the flood of plans, pamphlets, newspaper articles, and the revisions of theatre ordinances, etc., which came forth immediately after the calamity of the Ring Theatre fire in Vienna, in December, 1881; or the sentiment in favor of better means of safety which was aroused by the theatre fire at Exeter, in September,

in the United States in matters of theatre safety, and has been fighting an uphill battle of theatre protection for many a long year. His writings are well known to all concerned, and have not only served as a guide to the legislators of his own country, but also in the 'Old World.'

"That Mr. Gerhard should now — as an honorary corresponding member of the Committee — have contributed so courteously to our publications is a matter of congratulation, and I need scarcely express the appreciation of the Executive of the value of the assistance given, otherwise than to indicate that we also look upon Mr. Gerhard as an example to his fellow corresponding members, in respect to the assistance given in our work. . . ."

1887, in England; or the intense public excitement following the deplorable disaster of the Paris Charity Bazaar fire, in May, 1897; or finally, the horrors of the recent catastrophe of the burning of the Windsor Hotel, in New York, which occurred in the afternoon of St. Patrick's day, March 17th, 1899, and caused the loss of many lives. In every instance mentioned — and these instances might be multiplied indefinitely — the public excitement which followed the casualty did not last more than a few weeks.

Now I hold that the subject is too important to be dismissed so soon from our thoughts. The interest in this grave question should, on the contrary, be kept up and maintained, and measures of safety agitated, until all dangerous public buildings are either made perfectly safe or are closed up. Owners or managers of theatres, in particular, must be given to understand that their highest duty toward the public lies, not in giving them attractive performances, but in providing absolute safety to the public while assembled in their buildings.

GENERAL CONSIDERATIONS.

To begin with, let me state that I shall confine my remarks to a consideration of safety measures for the theatregoers and the performers and stage-hands. I shall leave out of consideration the question of the safety of the

building,— in other words, the subject of protection of property from fire,— except in so far as the safety of the building incidentally helps to increase the safety of the people assembled, during a performance, on both sides of the curtain. The safe construction of the building and measures tending to reduce the immense losses due to the destruction of such buildings by fire are no doubt desirable, but compared with the problem of how to avoid the terrible loss of life due to theatre-fire calamities, they are of secondary importance only. Besides, the matter of safe construction has been well and thoroughly discussed in numerous excellent treatises of which I would only mention the recent standard work by Mr. Edwin O. Sachs, on "Modern Theatres and Opera Houses." Another reason why stress will not be laid upon fire-resisting construction, and which will be brought out in what follows, is that incombustible or fire-proof construction, *per se*, cannot and does not absolutely prevent theatre-fire disasters. For instance, an ill-planned theatre, having its exits badly arranged or insufficient in number, may, in case of a real or false alarm of fire, prove a veritable death-trap, though its construction may be thoroughly fire-proof; and vice versa, a theatre which is combustible, which has wooden staircases, and which lacks fire-extinguishing appliances, may yet be so planned and arranged as

to afford the public perfect means for quick escape from smoke and fire, and therefore be the safer of the two. This instance indicates clearly that there are other safety measures of much more importance than fire-resisting construction.

A study of the principal causes of theatre fires and panics and of the dangers which arise in such cases should form the basis of the subject of prevention. It also offers the best clues for the essential requirements to be insisted on for the protection of theatregoers and performers.

According to the carefully compiled statistics of Mr. Foelsch and Mr. Sachs, 207 fires out of a total of 401 of which the cause could definitely be ascertained, or somewhat over fifty per cent, had their origin either on the stage or near the stage in the stage part of the building. The causes of these fires were defects in the gas installation, unprotected gaslights, careless or defective arrangements for the lighting up of the gas, defects in the heating apparatus, fireworks, lamps, explosions, firing of guns, and defects in the electric light installation. Therefore, the stage in a theatre is the point where the majority of fires break out, and the stage construction, the scenic apparatus and its lighting, require above all to be improved and made safe, if theatre fires are to be reduced in frequency.

When Mr. Foelsch's first paper on "Theatre Fires" was published, in 1870, he had collected statistics of 130 fires; when his book came out in 1878, it contained a record of 523 fires; the appendix to his book, issued in 1882, increased this number to 631, and in his last essay on theatre fires, published in 1889, he enumerated 936 fires. Mr. Edwin O. Sachs, who continued the work of Mr. Foelsch, published in 1897 a list of 1,115 theatre fires (up to May, 1897).

In his last book, "Reminiscences from the Life of a Civil Engineer," Mr. Foelsch gave the following statistics, in intervals of six years:—

From	1841–1846	occurred	32	theatre	fires.
"	1847–1852	"	41	"	"
"	1853–1858	"	40	"	"
"	1859–1864	"	41	"	"
"	1865–1870	"	82	"	"
"	1871–1876	"	96	"	"
"	1877–1882	"	161	"	"
"	1883–1888	"	215	"	"

The point brought out by these statistics is that the average number of theatre fires per year is on the increase. This agrees with the deductions from statistics as given by Mr. Sachs. While the average annual number of fires in the last thirty years is twenty-seven, the average of the last twenty years is thirty-three, and that of the last ten years is thirty-

six. This may be partly due to the increasing number of theatres erected, and partly, possibly, to the fact that the statistics of the last decade are more accurately kept. Still, one would hardly expect such a startling result in view of the numerous really valuable suggestions made from time to time regarding improvements for the safety of theatres.

Occasionally, one finds the subject divided into measures of safety to be applied to *old* buildings, and those that should be carried out in *new* buildings. From my point of view, this division is unimportant, except in so far as the older buildings are naturally more dangerous, and likewise more difficult to improve, than theatres of more recent construction, which, as a rule, are better planned, better constructed, and better equipped and maintained. On the whole, the principal measures of safety apply to both classes of buildings, and they can be carried out with only few exceptions whether the building is old or new. Of course, those who wish to avoid risks always go safer by shunning the older buildings and patronizing only the recently built theatres, at least in the larger cities, where special theatre ordinances are enacted. For instance, a very little reflection ought to teach theatregoers that theatres in which the electric light is installed, particularly on the stage, are less dangerous than those still provided with gas illumination,

or that theatres necessarily located in a block are much safer if there are large courts on each of their sides, giving numerous means of egress to the open air in case of an alarm or panic.

In my paper I shall have in view constantly the dangers from fires or panics breaking out *during* a performance. Statistics show that during the last hundred years (1797–1897) at least 9,355 persons lost their lives in theatre fires. This loss of life seems so appallingly large as to make it certainly worth while to make continued attempts to minimize the dangers to which people crowded together in a theatre during a performance are exposed. Mr. Sachs, in his work on "Fires and Public Entertainments," which forms a continuation of the statistical figures gathered with so much diligence and labor by the late engineer Aug. Foelsch, informs us that out of 769 theatre fires, 103, or about 13.5 per cent, broke out *during* the presence of the audience. These figures certainly point out the graveness of the dangers to theatre audiences and stage personnel. Dr. Brouardel, in an interesting article on "La mort dans les théâtres," explains wherein these dangers chiefly consist. He tells us that loss of life in theatre fires or panics is caused by burning due to the fire and the flames; by suffocation due to the heat, the smoke, or fire gases; by shock or fright; and by the crush or jam of the panic in which peo-

ple are trampled to death, or have their chests crushed in and die from hemorrhages, etc.

It follows that in the case of a fire or panic the chief and essential conditions for the safety of the human beings are first, *fresh air* to prevent suffocation by smoke and gases, and exhaustion by the heat of the flames; second, *light*, for darkness leads to confusion, frantic struggles, and crushes; and third, *plenty of unobstructed exits* leading to outdoors, for the lack of proper exits, and obstructions in passageways or on stairs, lead to jams and cause many violent deaths.

In considering the principal measures of safety for spectators, players, and stage-hands, I shall not, in this paper, follow the usual course of describing and discussing the various parts of a theatre building, their planning, construction, arrangement, and equipment, but I shall consider the safety measures as nearly as possible in what appears to me to be their relative order of importance. Fire protection in theatres includes the following safety measures, viz.: —

1. Means to permit the audience and the stage personnel to make their escape safely in case of either fire or panic.

2. Measures tending to prevent an outbreak of fire, and for quickly detecting and signaling a fire outbreak.

3. Measures for protecting the playgoers against fire and smoke.
4. Means for the protection of the stage personnel.
5. Measures for confining a fire to the stage and preventing its spreading.
6. Means for saving life.
7. Means for fighting fires in their incipiency.
8. Measures to guard against a panic.

1. MEANS TO PERMIT THE AUDIENCE AND THE STAGE PERSONNEL TO ESCAPE IN CASE OF FIRE OR PANIC.

Under this heading will be considered the question of theatre exits, which safety measure I place at the head of the list, because it is by far the most important measure. In this all leading authorities are agreed. The safety of the persons assembled in a theatre building depends more upon properly arranged means of egress than upon fire-resisting construction or upon the provision of suitable fire appliances.

Experience teaches that a theatre fire may become fatal to life within five minutes after the discovery of the fire. What must be done, therefore, in every such building, whether old or new, is to provide such means of egress as will insure the emptying of the entire house within three or four minutes. Rightly carried

out, this safety measure is entirely sufficient to save the lives of all people, spectators as well as performers, even when all other precautions, be they ever so good, are neglected.

But there is still another reason why the question of theatre exits is *all important*. Frequently false alarms of fire occur in a theatre, or a small stage fire is put out in its incipiency, yet sudden terror may seize the audience, and though their lives are threatened by neither flames nor smoke, they become panic-stricken, and a wild stampede towards the exits occurs. In such a case, the safety of the audience from the danger of being trampled to death or crushed in the jam depends entirely upon a provision of proper and sufficient exits to afford a possibility of quickly reaching the open air.

Under "exits" should be understood much more than merely the exits proper. We must include under this term the arrangement and dimensions of the seats, the width of the passages between the seats, the number of seats between aisles, the width and number of aisles, the size of the gangways in the rear of the seats in the auditorium, the arrangement of vestibules, foyers, and lobbies; the dimensions, planning and construction of staircases; the fire-escapes and balconies; the arrangement and width of exit-doors; the door-bolts, and the lighting of the exits. In other words,

the term "exit" includes the entire road which a spectator seated in the audience has to travel in order to reach the open air.

In Publication No. 4 of the British Fire Prevention Committee the subject of "Theatre Exits" has been admirably treated by Mr. Alfred Darbyshire, and Mr. Thos. Blashill has referred to the same subject in his paper on "Lessons from Fire and Panic." Mr. Edwin O. Sachs, architect, has perhaps struck the key-note in the following most important advice, which theatre owners and managers would do well to take to heart: "Everything to insure good exits should be done, even if some of the other requirements of modern theatre construction have to be given a second place. As far as the audience is concerned, suitable exits and straightforward planning should be given precedence." Equally true is the statement of Mr. Darbyshire: "Construction may minimize the risk of a fire outbreak, equipment may prevent the spread of fire, but clear exits and good planning will principally contribute to the safety of an audience."

This problem of how to secure a quick and safe departure of a theatre audience is largely a question of its proper and sufficient subdivision. While this is, to some extent, secured *a priori* by the division into different tiers, this in itself would not be sufficient, particularly if exits from different tiers are made to lead into

Byron for Library!

* This book is sent to the Editor by its author in the hope that he may find it useful in again bringing before the attention of theatre managers, municipal authorities, and the public the all-important subject of SAFETY in the THEATRE and in OTHER PLACES OF AMUSEMENT. **

Although written some years ago, its recommendations are just as applicable at the present day*

The author would appreciate it if clippings of a notice of the book or of an editorial be mailed to him*
89 STRONG PLACE, BROOKLYN, N*Y*

The Author.

October 1910.

a common lobby. Each section should be again divided and made to leave by several independent outlets. In other words, the audience in the parquet, balcony, and gallery, should each be decentralized as much as possible. The exit passages from different sections should, under no circumstances whatever, cross each other, meet, or be combined; each subdivision should have *at least* two entirely separate and independent exits leading to the open air; in large buildings a greater number even may be required. The spectators occupying gallery seats have the farthest to travel, and should therefore have the best facilities for exits, whereas actually the reverse is but too often the case.

It is not at all necessary that all the exits provided in a theatre should be used as entrances before the performance begins; but it is essential that all exits should be used nightly, *after* the performance, so as to familiarize the public with the different routes of travel. Nothing, to my mind, is worse in a theatre than the provision of so-called "*emergency*" exits, which are supposed to be used only in case of threatening danger.

The number of exits will depend upon the number of tiers and the size of the theatre; the number of tiers should be limited, and the gallery should not be located too high above the street level, nor should the main audito-

rium ever be located a story above the street floor. In general, smaller theatres may be considered safer than larger houses. The arrangement of a sunk pit, so common in English theatres, is unknown both in the United States and in Continental theatres. The pit arrangement is good in so far as it reduces the height of the upper gallery above the street level and thereby shortens the exit from the most dangerous part of a theatre. In the United States, building regulations call for the principal floor of the theatre to be not more than a few steps above the sidewalk.

The arrangement and placing of the exits will depend upon the plan of the theatre, and this, in turn, is determined by the available site. Clear planning is most desirable so that in the event of danger the audience may clearly see their way out; as a rule a symmetrical arrangement of both sides of each tier will conduce to the quicker emptying of the theatre.

It would be well to institute in newly completed theatre buildings actual tests of the time required to empty them. According to Foelsch, a theatre in Milan, Italy, having thirteen exits opened, was emptied in June, 1887, in less than four minutes (the size or capacity of the house is not stated). I am informed by a person who has frequently visited the Wagner performances that the Bayreuth Theatre, having a capacity of 1,500 persons, can be

emptied in just two minutes. The Fifth Avenue Theatre in New York (holding 1,400 persons) can be emptied in two and one-half minutes; Keith's New Theatre in Boston (3,000 persons) in four minutes; the recent Abbey Theatre in New York (1,450 persons) in one and one-half minutes. The large Madison Square Garden in New York, which holds 17,000 people, requires four and a half minutes for emptying. All these are examples of more recent buildings.

The minimum width of an exit and exit-door for 500 persons or less should be five feet, and for every additional 100 persons twenty inches should be added to the width.

Regarding the arrangement of the exit-doors, it is of the greatest importance that these should swing outward, for many a disastrous panic and loss of life has been caused by doors which opened the wrong way, and which could not be opened during a jam because the maddened crowd was pressing against them in their frantic efforts to reach the exits. It is not sufficient that doors should open outwards, but they should swing entirely out of the way in order not to form, when opened, an obstruction in a passageway or staircase.

All exit-doors should be plainly designated as such in large legible letters; all other doors may be either marked "No exit," or should have the name of the room into which they

open marked, such as "Cloak-room," "Toilet-room."

Doors of exits leading to staircases should never open directly upon the stairs, but there should always be a wide landing between the doors and the stairs to prevent people from stumbling. Under no circumstances should doors with lock and key be tolerated in a theatre; exit-doors may be provided with bolts placed on the inside and at shoulder height, and of such construction as to be easily drawn or pushed back. Several so-called panic bolts are now obtainable which fulfil the requirements of safety. In the Abbey Theatre of New York City the exit-doors are controlled by electric openers, which are operated by pressing a button, either from the stage or from the manager's office. The device is, perhaps, not new, for it was proposed in 1882 by a clergyman, Don Ravaglia, and tried with success at the Allighieri Theatre, in Ravenna, Italy.

Regarding the staircases in a theatre, these should be wide and easy; they should never have any winding steps, nor should there be single steps. Very long stairs should be broken by wide landings. All risers and treads should be uniform to prevent stumbling. Stairs should be at least four feet six inches wide, and if possible they should be made wider than the width of the corridors leading to them.

A strong and well-fastened hand-rail should be provided at both sides of the staircase, and very wide stairs should be divided in the middle by a centre rail. No obstructions of any kind should be permitted in staircases of theatres. Concerning construction, it is desirable, though by no means absolutely necessary, that the stairs should be fire-proof or incombustible. Ill-planned fire-proof stairs may not prove to be as safe as well-arranged wooden stairs. Iron stairs with slate treads are better than stone stairs. Stairs enclosed on both sides with brick walls are better and safer than open-well stairs. It is quite essential that stairs leading to the exits should be smoke-proof.

All corridors, halls, and passages should be planned of ample width to accommodate the number of people passing through them. They should be not less than three and one-half feet wide for 200 persons, and for every additional 100 persons six inches in width should be added.

The aisles in the auditorium should be of proper width, and sufficient in number, as this will assist greatly in the quick emptying of the house. The minimum width of aisles should be three feet, and it is desirable that the width of the aisles should increase toward the exits. Aisles should never have steps, but must be planned with gradients or inclines.* All pas-

* For the aisles of the upper tiers this requirement cannot be carried out. — W. P. G.

sages and aisles should be kept free and unencumbered; no extra chairs, camp-stools, or other temporary obstruction should ever be permitted. There should be a sufficient number of aisles between the seats, so that persons in leaving may quickly reach the aisle. Most theatre regulations prescribe that there should be not more than twelve seats between aisles. The dimensions of the seats should be generous, not only for comfort's, but principally for safety's, sake. The seats should be from eighteen to twenty-one inches wide, and the distances between the rows of seats should be from twenty-nine to thirty-one inches (generous dimensions are twenty inches wide and thirty-three inches deep). All seats should be well fastened, for loose chairs might become, in times of panic, a dangerous obstruction by accidental overturning. The seats should be so-called flap-seats, hinged so that they may be turned up out of the way, thus affording more room between the rows for people passing between them.

The gangways or passages at the rear of the auditorium seats and all foyers, vestibules, lobbies, colonnades, or terraces reached by the playgoers from the aisles should be generous in size, and of capacity to hold the entire number of persons of each tier. They must be well ventilated, and be free from any smoke. Each tier must, in addition to the regular exitways,

be provided with external iron safety balconies and iron fire-escapes, leading to the open courts in those theatres which have only one front on the street. These fire-escapes should be constructed so that they can be well and conveniently used by women, children, and infirm old persons generally. It is very necessary that the external fire balconies and stairs be covered or roofed over, so that they may not become slippery and dangerous in freezing weather. It is also important that these fire balconies and stairs be kept at all times entirely free and unobstructed.

Given plenty of exits through which a crowd may safely escape in case of fire or panic, it is necessary that all exits, passages and corridors and stairs, including, as I believe, the rear portion of the auditorium, be lighted by some lighting system entirely independent from the lighting system of the stage or the main auditorium. Where gas or electric light is used in the theatre, it is usually required that the exits be lit by vegetable oil lamps, or candles, but either of these should be well protected from draughts. If gaslights are used, they should be supplied from an entirely separate gas service, and the gaslights should be controlled by gas keys with detachable keys, in order to prevent mischievous persons from tampering with the lights, which are so absolutely essential to the safe retreat of an audience.

The safety measures named will secure the safe escape of the playgoers from a theatre in case of a false or real alarm of fire. Equally necessary are the means for the safe escape of the theatre personnel, comprising the performers, musicians, dancers, stage-hands, etc. In some performances there are sometimes as many as three or four hundred people behind the curtain, and their safety is of as much importance as that of the theatre audience. The stage-house therefore requires several properly arranged and located exits, leading directly to outdoors and preferably located on the two opposite sides of the stage. There should be wide passages around the three sides of the stage, divided from it by fire-walls. There must also be well-arranged, strongly built stairs leading from the dressing-rooms of the actors to the exits, and these stairs should in every respect be as safe as those for the audience; they must be smoke-proof and kept well lighted until the emptying of the stage-house. The dressing-rooms should not be located too high above the stage, nor up near the rigging-loft, from where escape is more difficult.

For the stage-hands there must be at least two fire-proof stairs leading from the flies and the rigging-loft down to the stage.

2. MEASURES TENDING TO PREVENT AN OUTBREAK, AND FOR QUICKLY DETECTING AND SIGNALING A FIRE.

We have seen, in the foregoing remarks, how very necessary it is, in case of a fire breaking out in a theatre building during a performance, to get the people out of the building as quickly as possible, and in such a manner as to prevent any panic, jam, or stampede.

We must now consider briefly some of the general measures which will tend to prevent an outbreak of fire. These measures comprise chiefly four points of consideration; namely, the site and plan of the building, the construction and equipment, the managing and watching, and finally the theatre inspections.

Regarding the site for a theatre, a free site is, of course, the ideal one. In some Continental cities this is insisted upon, but in both England and the United States of America a free and isolated site is very exceptional. Most American theatres have only one street front, and until quite recently many such buildings were badly hemmed in on the sides so that it was almost a matter of impossibility to provide a suitable number of safety exits. In recent theatre buildings located in the middle of a city block, a compromise has been effected by making provision for wide courts on both sides of the front. Some of the stage exits and the outside fire-stairs lead into these courts,

which must have a certain minimum width, depending upon the number of persons which the theatre holds.

In choosing the site for a theatre, due regard should always be had to the neighborhood and the surroundings. A theatre should never be located near dangerous trade establishments, large factories, etc. Danger of fire from without should be guarded as much as fire from within. The location of a theatre in rear courts, with entrances passing through front buildings devoted to other purposes, is one that is universally considered out of the question.

The general arrangement of the plan should be as clear and symmetrical as possible, as this increases the safety. The number of tiers should be as small as possible, and never more than three tiers above the parquet. The subdivisions comprise the parts devoted to the public, such as the entrances, stairs, vestibules, foyers, and the auditorium; and on the other hand, the parts devoted to the players, viz., the stage, the dressing-rooms, the manager's offices, the property-room, the scene-dock, the engine and boiler room, etc. It is well to eliminate from a theatre building in the front part of the house all stores, living apartments, restaurants provided with kitchens, etc., and from the stage part of the building the scene-dock, the painters' and carpenters' shops,

the steam boilers, the gas-meter vaults, the property and costume rooms, in short all rooms for storage of a considerable amount of inflammable materials, etc.

It is not my purpose in this paper to discuss theatre construction, except to indicate, in a general way, that as the safety of a building has a direct bearing upon the safety of the people in the theatre, all walls should be well-built, solid fire-walls, and that there should be as many subdivisions as practicable, each made as fire-resisting as possible, and divided from the adjoining division by properly constructed fire-walls. Besides, the theatre should have a fire-proof roof to guard against danger of a conflagration from the outside. All chimney and smoke flues should be built in the very best manner possible.

As explained heretofore, the stage of a theatre is the chief danger-point, hence particular care is necessary to make it as fire-resisting as possible. The stage is the place where a vast quantity of very inflammable material, such as woodwork, canvas, paper, ropes, is concentrated. The scenic decorations are naturally subjected to a constant drying-up process by the great heat to which they are nightly exposed. They are always to be considered as being in danger of fire from their exposure and closeness to open lights, wherever gaslight is still used, and they are apt to catch fire very

quickly. It is self-evident, therefore, that the stage should be made much safer than it is found to be in the majority of theatres, by eliminating from it combustible material as far as practicable. The central part of the stage must necessarily remain a wooden construction, owing to the requirements of the numerous stage traps, but the two sides of the stage, the so-called wings, the fly-galleries, and finally the gridiron and the stage roof can and should be constructed of fire-resisting material. Moreover, all scenic decorations can be rendered safer against catching fire by being impregnated with chemicals. All woodwork, the scenery, and finally the costumes, particularly the light gauze costumes worn by the ballet-girls, should be rendered non-inflammable by impregnation, which in the case of dresses must be repeated after each wash. The canvas scenes may be covered with fire-proof paints, and indeed one may go a step further and substitute for the wooden and canvas decorations those of sheet-iron held in light iron frames, or else asbestos cloth, as urged by modern stage reformers. Instead of hemp cords, wire ropes should be used, and for the wooden drums and hoisting apparatus the more modern hydraulic or the electric stage appliances should be installed. No scenery accumulation should be permitted on or near the stage, and special fire-proof scene-docks should be provided for the purpose beyond the limits of the stage-house.

A special point, namely, the lighting of the stage and of the decorations, requires some mention. We know well that most fires originating on the stage are due to defective stage-lighting or to open flames, hence the stage-lighting should be modified. Such a modification — nay, revolution — came about with the introduction of the incandescent electric light. It is scarcely necessary for me to praise its many points of superiority over gas-light for the theatre stage, for its advantages are now well recognized. Of course, its installation does require careful attention to the details, but with wiring well insulated, and with motors and dynamos located in a special annex, nearly all danger is eliminated. That electric lighting is not absolutely safe is again demonstrated by the entire destruction by fire of the Théâtre Français, in Paris, on March 8, 1900. The origin of this fire, which fortunately broke out one hour before an afternoon performance, is generally attributed to a defective electric-light wire. One person, an actress who was in her dressing-room after rehearsal, became suffocated by the smoke and lost her life in this fire. This instance points again to the necessity of frequent examinations of the electric-light installation. In general, it may be said that the electric light is not only brilliant, but readily brought under control. It does not vitiate the air, and above all, it does not create the fierce

heat which is due to the numerous gas-flames serving to illuminate a scene. Finally, it does away with the dangerous lighting-up processes of rows of gaslights, and thus eliminates one of the dangers inherent to the gas-lighting system. Hence the use of electric light instead of gas is rightly considered one of the best measures to prevent a fire in a theatre. It is, perhaps, unnecessary for me to mention specially that the above recommendation of the electric light is confined to the incandescent light only, for the arc-light must be regarded as rather dangerous for use on the stage of a theatre. Where, however, electric light is not available, and gas must be used, special pains should be taken to reduce the accompanying danger as much as possible, particularly where open flames must be used, which should always be well protected. Care should also be taken in using the best available means for the lighting of rows of gaslights, particularly those which illuminate the battens, and likewise should care be bestowed upon movable gas-hose connections for shifting pieces of the scenery. The lighting of the stage and of the main part of the auditorium, excluding the gangways at the rear of the seats, should be controlled from a gas-table on the stage, and the lighting of stairs, corridors, lobbies, foyers, should be entirely separate and controlled from the foyer only.

To render a theatre safe, there should be but one central heating apparatus. Heating by steam is preferable to furnace heating, which latter has a tendency to render the inside trim very dry.

Every theatre building should have sufficient protection against lightning. The protection which a proper system of lightning-rods affords should not be underrated. Lightning-rods may prevent the outbreak of fire, and they may likewise serve to avert a serious panic, which may follow where a theatre building is struck by lightning. In August, 1894, the Royal County Theatre at Reading, England, was struck by lightning and the resulting fire completely destroyed the building, which fortunately was empty at the time. In several instances where theatres were struck by lightning during a performance, the panic which followed resulted in the deaths of several people. Quite recently, on the night of June 7, 1899, a theatre at Chautauqua Lake, in the State of New York, was struck by lightning while a play was in progress. "With the crash all the lights went out, but the audience was prevented from stampeding by the coolness of an actor." Still more recently, on the night of Sept. 5, 1899, Robinson's Theatre in Cincinnati, O., was struck by lightning during a heavy rain-storm, and the entire fire depart-

ment had to be called out, as the flames immediately burst forth.

A further safety measure to prevent an outbreak of fire consists in the efficient watching of the theatre building, particularly before and during a performance. The inspection should be directed particularly to the heating and lighting apparatus of the theatre. Many fires break out within two hours after the close of a performance, hence it is an excellent precaution to have the entire building carefully gone over and watched nightly. To insure safety of the spectators, however, with which we are principally concerned, it is necessary to maintain in a theatre, during the entire performance, an efficient fire-watch, composed of well-drilled and experienced members of the city fire department, and to institute and maintain daily inspections before the performances. The latest theatre fire at Paris, of the Théâtre Français, brought to light the fact that in Paris theatres there is no fire surveillance except during performances.

Then again, safety is attained by having regular periodical inspections of the building by fire experts, architects, engineers, and firemen, and also special inspections and actual tests of the gas-piping, of the electric appliances, of the water and fire-extinguishing appliances; also tests of the efficient working of the stage-roof ventilators, to which I will refer hereaf-

ter, of the fire-alarm apparatus, of the heating apparatus, and of the lightning-rod protection. Besides these, there should be occasional inspections by the authorities, which should preferably be unannounced.

Every theatre should be provided with the most improved and modern means for quickly detecting, reporting, and signaling an outbreak of fire. This includes an automatic fire-telegraph system and telegraphic or telephonic communication with the nearest fire-engine house, with fire-department headquarters, with the city-water reservoir or water-department headquarters, and with the station-house of the life-saving patrol.

Finally, many measures tending to prevent an outbreak of fire are matters belonging to theatre management. Every theatre manager should issue rules of order and should see to it that they are strenuously enforced. He should insist upon, and maintain, strict discipline and order in all parts of the building; he should maintain regular fire-drills carried out by the stage employees and the theatre staff. Instruction should be given in the use of the fire-extinguishing and life-saving appliances, and special instructions issued to the watchmen in the theatre.

Gas leaks should be immediately reported; lamps on the stage, if required, should be handled with care, and all exposure to draughts

avoided; the use of alcohol-lamps in the dressing-rooms should be forbidden; safety lanterns or electric candles should be provided for use in entering large costume or property rooms; extreme caution should be exercised in the lighting of foot and batten lights of gas, and in the use of matches, candles, oil-lamps, firearms, fireworks, representations of conflagrations in spectacular plays, benzine or turpentine in workshops or costume-rooms. Smoking should be rigidly prohibited in all parts of the house, including the actors' dressing-rooms, and be permitted only in a special fire-proof smoking-room. All accumulation of rubbish, straw, oily rags, etc., and combustible material, liable to spontaneous combustion, must be avoided. No obstructions of the fire appliances should be permitted. The manager should not only enforce the greatest carefulness of persons on or near the stage, but also insist upon the constant and nightly use of the fire-proof curtain; he should see personally that all exits are constantly used and that they are kept efficiently lighted until all persons have left the building.

3. MEASURES TO PROTECT THE AUDIENCE FROM FIRE AND SMOKE.

We have now discussed two principal safety measures; namely, first, the exits and their proper arrangement to enable an audience to

make their safe escape under all circumstances, and secondly, measures tending to prevent an outbreak of fire. We must now point out two important further measures, which have for their object the protection of the audience, in case of an actual outbreak of fire, from both the fire or the flames and from the smoke and fire-gases incidental to every theatre fire. Dr. Brouardel has given a very good description of what happens when a fire breaks out on the stage of a theatre. In the majority of cases the fire originates from stage decorations catching fire, and owing to the inflammable nature of the material usually adopted for them, large volumes of thick smoke are at once generated, which contain both carbonic acid and carbonic oxide. The flames, the fire-gases, and the smoke at once jump from the stage into the auditorium, particularly into the upper galleries, and within a very few minutes, incredible as it may seem, their deadly work is accomplished, and hundreds of people may be killed, partly by the heat and the flames of the conflagration, partly by the deadly gases which render respiration impossible after only three or four minutes. In many of the theatre-fire calamities recorded the deaths were due principally to suffocation by carbonic oxide, or by the inhalation of hot air. As proof of this assertion Dr. Brouardel cites the fact that the dresses of many of the victims were found un-

scorched, dead bodies were found with the eyebrows and whiskers unsinged, and the bodies bore no marks of scalding, nor were they covered with blisters. Further proof that death was caused by carbonic-oxide poisoning was given by the analysis of the blood, which was found to contain carbonic oxide.

To guard against the dangers thus described, two important safety measures have been devised, which can readily be introduced into every theatre building, whether old or new. One of the measures consists in the use of a fire-proof and smoke-proof curtain in the proscenium opening, to divide the auditorium from the stage; the other consists in providing large smoke flues, outlets, or ventilators in the roof of the stage.

The fire-wall dividing the stage-house from the auditorium would not constitute a protection in case of fire, owing to the large stage-opening. This should, therefore, be closed by a fire-proof curtain.

Numerous discussions have been held about the best material for such a curtain. In Continental cities and also in England preference has been given to iron curtains, either of wire, or of flat or finally of corrugated iron. Flat iron curtains have not, in practice, proven sufficiently strong to resist the air-pressure from the stage in case of fire, and they have sometimes buckled out in the centre and thus

proven inoperative. Wire curtains prevent the passing of flames from the stage into the auditorium, but permit the passage of the deadly smoke, and moreover they give the audience, already panic-stricken, a full view of the fire, and thereby increase the rush to the exits and the wild excitement. Corrugated iron curtains are by far the best of all iron curtains, as they are strong and fire-resisting, and at the same time, if properly fastened and guided at the sides, they are smoke-proof. They are, of course, heavy to handle, and must be well counterbalanced. The best iron fire-curtains are doubtless those operated by hydraulic machinery. The mechanism for the raising and lowering of the curtain must be perfect from a mechanical point of view; this mechanism should be operated from the level of the stage, and preferably also from another accessible point. Several cases are on record where iron fire-curtains became stuck in the grooves when it was intended to lower them. It is stated that when the fire broke out which destroyed the Théâtre Français in Paris, the iron stage-curtain was found not to be in working order. Accidents have also happened by the curtain falling down on the stage. Flat iron curtains have been bent and thrown by the strong air-pressure due to the expansion of the air by the heat of the fire into the auditorium. A much more practical fire-curtain consists of thick and

strong woven asbestos cloth, well guided in iron guides at both sides of the proscenium-opening. Such curtains are used exclusively in modern American theatres, and it is believed by experts that they are sufficiently fire-resisting to keep flames and smoke from the audience until all have escaped by the numerous exits which are provided in modern playhouses. The fire-curtain is kept lowered in the theatres until the beginning of the performance or the rehearsals.

With proper fire-walls between stage and auditorium, and no openings in these above the level of the stage, and with a good fire-curtain, a fire breaking out on the stage will successfully be confined to this point until the house has been emptied and all the persons saved.

The other, equally essential, requirement consists of large outlet openings for the smoke provided in the roof over the stage. These openings may be formed of regular vent flues, or they may be special forms such as sliding skylights, which are quickly opened in time of need, or which operate automatically. It is important that the ventilators should be of sufficient area to remove the volumes of smoke generated by the burning of much inflammable scenery. Some regulations require their combined area to be one-tenth of the area of the stage. When they consist of flues, their

lower end may be closed by a light muslin or other substance easily destroyed when the flames first reach the stage roof, or they may consist of automatic sliding ventilators like those of the new theatres of New York City. Finally, the flues may be closed by registers operated from the stage by ropes or other appliances.

The chief object for which they are intended is that there should be created a strong draught from the level of the stage floor up to the roof, and away from the auditorium. This will afford a very good protection to the theatre audience, certainly until they have had time to make their escape in safety.

Should there be in the ceiling of the auditorium a ventilator, possibly even assisted by the upward draught created by the now obsolete central chandelier, it is necessary that arrangements should be provided for closing the ceiling ventilator to prevent a draught from the stage towards the ceiling vent in the auditorium. In Europe, several theatres have arrangements by means of which it is possible to close by one movement this ventilator and simultaneously to open the stage ventilators. The stage roof being invariably higher than that of the auditorium, it is natural that the draught towards the stage should be the stronger, and that thereby the audience will be protected against smoke.

The diffusion of smoke from the burning scenery into the staircases both of the part of the house before the curtain and in the stage-house should be efficiently guarded against, hence the requirements that corridors, lobbies, and staircases for the public as well as for the stage people should be smoke-proof. Doors should be provided between the auditorium and the foyers and corridors, likewise doors between the sides of the stage and the dressing-rooms.

Inside staircases are bad, as the air in them may become full of smoke, whereas outside stairs can generally have windows which will secure fresh air. Light in the stairs is also of importance, and therefore I have mentioned elsewhere that it is essential to have a separate system of lighting of the exits and corridors and stairs; this will prevent confusion in the darkness due to smoke, and often avert dangers to the people using the exits. The maintenance of the auxiliary lights in the exits is a very important safety measure which in itself will prevent direful confusion and a crush. These lights will also prove of great utility to the firemen when entering a burning building, and in some cases they may assist them in finding and rescuing persons who may have fainted or become overcome by the smoke.

The abolishment of the central gas chandelier in theatres is a great improvement, but the

ceiling ventilation in the auditorium cannot so easily be dispensed with, as during the times when the curtain is lowered there would otherwise be no ventilation for the auditorium. It is necessary either to arrange the ventilation on the so-called "downward" system, or else there must be provided a perfectly working appliance which will permit the ceiling ventilator in the auditorium to be closed whenever the curtain is raised, or at least when fire breaks out on the stage.

Regarding the auxiliary lighting of exits I would mention that where these consist of candles or oil-lamps they require to have lanterns encasing the lights, which must be provided with fresh-air ducts to keep the lights burning in case of smoke.

4. MEANS FOR THE PROTECTION OF THE STAGE PERSONNEL.

It is not sufficient that we should protect the audience from fire and smoke; the people behind the curtain are deserving of the same considerations for their safety. Owing to the fact that fires in the majority of cases break out on the stage of the theatre, the performers and stage-hands would be immediately and directly exposed to the flames, the fire-gases, and the smoke, unless proper means for their protection are provided.

Hence the dressing-rooms should be com-

pletely isolated from the stage-house, as well as from the auditorium; the part of the building in which they are located should be isolated by fire-walls, and by a wide fire-proof corridor. There should be wide, well-lighted fire and smoke proof staircases for the performers, one for each side of the stage. These should lead directly to the courts on each side of the theatre, or to outdoors where the building stands isolated. The dressing-rooms should have windows to the outer air, and these should never be guarded with iron bars or grilles, which would render escape through the windows impossible; additional iron fire-escapes at these windows are desirable. It is advisable not to put the dressing-rooms of the actors too high up above the stage level, as this would necessitate a long route in case of an alarm. Regarding the size and dimensions of the stage-exits and exit-doors, the same rules as for the audience should apply, and they should be proportioned to the largest number of persons which may be on the stage and behind the curtain generally.

For those workmen who are employed during the performance in the fly-galleries or the rigging-loft, there must be provided an iron staircase, or preferably two, one on each side of the stage.

The greatest safety for the stage personnel is attained, of course, by adopting a better con-

struction of the stage, and doing away with as much woodwork and inflammable scenery as possible, or at least, where the cost of an iron construction cannot be borne, the scenery and the woodwork should be rendered uninflammable by an improved fire-proof treatment by chemicals.

Greater safety is also attained by rendering the dresses and costumes non-inflammable by impregnation. Space forbids my going into the details of the various now available processes.

The stage ventilators and the automatic-sprinkler system will also be efficient means of protection, the former by removing the smoke, the latter by the chance which it offers to put out a fire among the scenic decorations in its incipiency.

Greatest care should be exercised in the planning of the stage and its accessories, and the success of a well-organized stage management will depend chiefly upon it.

In the actors' dressing-rooms attention should be paid to numerous small details tending to give greater security. Here all woodwork should be rigidly excluded, all open gas-flames must be well protected, and the smoking in dressing-rooms should be absolutely prohibited. The rules of the theatre management should emphasize the need of greatest care on the stage with lights, matches, lamps, torches, fireworks, and the use of firearms.

A properly installed electric-lighting system on the stage will form another efficient protection of the stage personnel, as already explained elsewhere in this paper.

Finally, it will enhance the safety of the stage personnel if the carpenters', painters', and tailors' workshops are completely isolated from the stage building.

Panic may break out on the stage as well as in the auditorium, hence, besides provisions against smoke and fire, means to avert a panic should be contrived, or at least, every possibility should be afforded to the performers and stage-hands to make their escape in safety, and to avoid a crush or jam with its often fatal consequences.

5. MEANS FOR LOCALIZING AND RESTRICTING A FIRE ON THE STAGE.

If, notwithstanding all possible precautions, a fire actually breaks out on the stage, all efforts should be concentrated toward restricting and confining the fire. Good planning and sound construction will do more towards accomplishing this desired result than any human efforts at fire-fighting. Let the stage building be planned and built so as to be completely isolated, forming a fire risk in itself, and half the battle may be said to be won. This is accomplished by the use of fire-walls surrounding the stage on all sides; again, the

fire-proof curtain, discussed in a former paragraph, will render efficient service in localizing the fire.

The proscenium wall should have as few openings communicating with the auditorium as possible, and these should be provided with fire-proof doors, of oak, lined on both sides with tin, and possibly arranged to close automatically. Again, it should be mentioned that the construction of the fire-curtain must be such that it will close at the sides and not permit the smoke or flames to pass through.

Proper roof-ventilators will assist in removing the smoke from the stage; but in case of fire, all doors leading to the stage should be instantly closed to avoid a draught.

Fire-extinguishing appliances, if kept in working order, and a well-organized fire-brigade composed of the stage-hands and stage machinists, will prove useful during the first outbreak of a fire. This was apparently not the case in the recent fire disaster of the Théâtre Français. There was not only lack of water, but the automatic-sprinkler apparatus was found to be out of order. An automatic fire-alarm system, regularly tried and maintained in good order, will indirectly help in localizing the fire by at once giving notice of the outbreak. Lastly, a good water service and efficient fire-pressure at the fire-hydrants will be the means to confine and restrict a fire. All

fire-extinguishing appliances are to be considered as chiefly useful during the first few moments after the outbreak, for as soon as the flames have begun to spread, these devices will prove powerless, and the building should be turned over to the quickly summoned fire department, while all efforts should be concentrated to save human life.

6. MEANS FOR SAVING LIFE.

In cases where a fire has spread and gained much headway, it may happen, notwithstanding all precautions, that the safe retreat of persons in the theatre is cut off by flames or smoke. Therefore, it is essential that every theatre should be provided with at least some means for saving life.

The outside fire-escapes belong, first of all, to these measures for safety. There should be provided, besides these, outside iron ladders, built into the walls, connecting the various roofs, and which may serve not only as means of escape for persons in the burning building, but which will prove extremely useful to the firemen in their work. In this connection mention should again be made of the necessity of omitting any bars or iron gratings at the windows.

All large cities, and many of the smaller ones, now have in their fire department a regularly trained corps of life-savers. They make

use of light but strongly built scaling-ladders to reach persons at the windows, whose retreat by the regular stairs and exits may have been cut off. In connection with these scaling-ladders it is worth while mentioning that, in the erection of the building, provision should at once be made for window cornices or sills so moulded and of such dimensions as to be adapted to the scaling-ladders.

The life-saving corps also make use of life-lines, of canvas belts with clutch-hooks, or portable rope escapes, and of guns for firing the life-lines into windows. They likewise use asbestos-cloth chutes or life-saving sacks of flexible canvas, which they carry up the ladders, fasten securely to windows, and by means of which persons in danger are readily rescued. Some fire departments use the jumping-net or cloth, and while by no means without danger to the limbs, a jump from a window into the jumping-net may save the lives of many persons.

The theatre management should consider the advisability of providing some of these means of saving life for the building. Extension ladders, scaling-ladders, possibly a chute, and some smoke-protectors should be kept in every theatre ready for use in emergency cases.

7. MEANS FOR FIGHTING OUTBREAKS OF FIRE.

Notwithstanding the assertion made in the first part of this paper, that the safety of the persons in a theatre is much more important than the safety of the building, it is necessary that every theatre should be provided with some means for fire extinction, and particularly such as are useful in extinguishing fires in their incipiency. As such fire-fighting appliances I would mention, first, the automatic-sprinkler system on the stage. This includes rows of pipes with sprinkler-heads, placed so as to command and protect every square foot of the understage, the stage proper, the fly-galleries, the rigging-loft, the engine and boiler room, the dressing-rooms of the performers, etc. They should be supplied from one or several roof-tanks of generous capacity, or from pressure-tanks in the basement, and these tanks should not be used for any other purpose, and must be kept constantly filled so as to be in readiness when wanted. The tanks are usually supplied from a large fire-pump in the engine-room. In addition, outside fire-department connections for the sprinkler system must be provided. The same fire-pump should be connected with the fire stand-pipes, of which there should be in every theatre at least four lines; viz., one on each side of the stage and of the auditorium. Larger theatres and opera houses require a greater number of stand-pipes.

There should be fire-valves on the stand-pipes at each of the floors, and each valve should have fire-hose of suitable quality, and of sufficient length, connected with it, and kept ready for immediate use.

Besides this, there should be a large number of fire-pails, for these are even more useful than the fire-hydrants to put fires out when just started, also small hand extinguishers, chemical extinguishers, and large casks of water to refill the fire-pails.

There should be on the stage, in the fly-galleries and in the rigging-loft, a full complement of fire axes, picks, pole-hooks, brackets, saws, hatchets, crowbars, safety lanterns, torches, or electric candles, and an assortment of portable ladders, also some wet blankets.

There should be, in the stage-house, a general fire-alarm, operating automatically; and the theatre should be in telegraphic and telephonic communication with the nearest engine-house, with the police station, with the fire headquarters, each of these to have a separate and direct wire connection with the theatre.

It has already been said that every theatre should have a fire-brigade composed of its stage-hands and men of the manager's staff; furthermore, during the performances there should be a special fire watch, composed of experienced and trained firemen of the regular fire department.

The management should order frequent inspections of all fire-extinguishing appliances; it should issue special rules regarding the non-use and the frequent filling of the fire-pails; it should provide an electric-float indicator from the roof-tanks, indicating in the engine-room and also in the manager's room how much water the tanks contain and when they are empty.

8. MEANS TO GUARD AGAINST PANIC.

All the measures discussed so far have in view the contingency of an occurrence of fire and the prevention of fire outbreaks. It has been explained, however, that one of the gravest dangers to be feared is the occurrence of a panic among the audience, caused by an alarm of fire. The alarm of fire may be real, or else, as frequently happens, it may be only a false alarm; in either case a dangerous stampede, jam, and crush may result. Moreover, it must not be overlooked that there are many causes or disturbances other than fire which may precipitate a panic. This something causing a panic may happen in the best-planned, best-equipped, and most safely constructed theatre just as well as in the most wretched and inflammable structure. It is of the greatest importance that everything which may tend to cause a panic should be avoided, as the result would usually prove as dangerous or fatal to

the theatre public and the artists as an actual outbreak of fire. The best system of fire-resisting construction, the best system of watching by trained firemen, the most careful inspection by experts and specialists, cannot prevent the outbreak of a panic, when there is only apparent, but no actual, danger.

It is well to study the possible causes of a panic not less than the causes of fires, for some of them at least may be avoided. Panics in theatres may originate either from imagined or suspected dangers — caused by malicious alarms, by misunderstandings, by fright, or by some cause trivial in itself — or else they arise from actually present and often visible dangers, fire, stroke of lightning, etc. The danger is aggravated by the fact now well known to many theatre visitors that it requires but very few minutes in a burning building for the smoke and fire-gases to suffocate people. This explains the terror, the wild fright, the haste and confusion, the loss of both courage and presence of mind, the dangerous stampedes, the mad struggles at the exit-doors, the trampling to death, and the jam following a panic. In such dire moments the instinct of self-preservation often drives people even to kill one another. Many of the older theatres have insufficient stairs, exits, and passages, and the result is that feeble or frightened persons may, in case of a sudden rush, stumble or fall when

pushed, and cause those who follow them to fall over them.

To say that there are no measures which will effectively prevent a panic is not correct. In my judgment, much can be done to prevent dangerous panics by giving the audience a feeling of security, and this they are bound to get, at least in some measure, when they know that the theatre is well planned and that there are at all times available plenty of wide, free, and unobstructed exits and fire-stairs, enabling the entire emptying of the theatre in less than four minutes; when they know and see that overcrowding and obstruction in the aisles are not tolerated, that the management does not sell a larger number of tickets of admittance than the theatre license permits, that no standing-room or camp-chairs in the aisles are permitted; when they are kept informed of the systematic and periodic inspections, and are told that there are nightly fire watches, particularly when dangerous spectacular plays are given; that the attendants are instructed in their duties in case of fire, and that there are frequent fire-drills. This feeling of comparative security is also fostered by the knowledge that there is a fire-proof proscenium curtain in actual use, that the stage roof is provided with ventilating skylights or smoke-flues, that there are well-built fire-walls separating the auditorium from the stage, and that the electric in-

candescent light is used to light up the scenic decorations.

The best preventive of a panic is doubtless the knowledge that there are more than ample facilities for direct and quick egress from all parts of the house. Therefore, for panic not less than for fire, the theatre exits and the clear planning are the two all-important requirements which must be fulfilled irrespective of all other safety measures.

Other measures which the management may institute and which will surely be helpful are the printing of the exits on the theatre programmes, the hanging up of clearly printed diagrams showing the plan of the building and the nearest exits, in the foyers and vestibules, the lettering of all exit-doors in large, easily read letters, the nightly use of all exits, the maintenance of plenty of light in the exit-passages, stairs, and courts, and instructions to theatre ushers about directing the audience to the nearest exits. Inasmuch as a sudden and unannounced darkening of the auditorium may scare nervous people and thus may precipitate a panic, it should not be practised except it is prominently announced either in the theatre programme or from the stage.

A safety measure which has been mentioned under a former heading, and which is also important to prevent panic, is to provide every theatre with lightning-rod protection.

CONCLUSION.

Summing up what has been said in the preceding pages, the following are the principal measures in the interest of safety of the persons in a theatre building, which should be carried out, irrespective of whether the theatre is a new or an old building: —

1. Free or isolated site.
2. Open courts on the sides of buildings located in a block.
3. Clear planning.
4. Plenty of wide, unobstructed exits, doors opening out, separate lighting of stairs, passages, and exits.
5. Fire-walls between auditorium and stage, and between stage and dressing-rooms.
6. Fire-proof curtain.
7. Stage smoke-flues or ventilators.
8. Electric incandescent light in place of gaslight.
9. Impregnation of all woodwork, scenery, decoration, and gauze dresses.
10. Fire watch and inspections.
11. Lightning-rod protection.
12. Automatic-sprinkler system.
13. Maintenance of fire-extinguishing apparatus for instant use in emergencies.
14. Means for instantly signaling outbreaks of fire.
15. Rules of management; control of the-

atres by municipality or building department.

16. Fire-resisting construction.

A careful review of the numerous propositions made to secure the safety of theatre audiences and the stage personnel shows a tendency to lay altogether too much stress upon fire-proof construction. To Mr. Sachs, I believe, belongs the credit of having pointed out very clearly and conclusively that the relative order of importance should be somewhat changed, viz., good planning should come first, next efficient and constant watching, then careful and frequent inspections, and lastly fire-resisting construction. After all that I have said it is not necessary for me to explain why fire-resisting construction is the least important of the four items, when we have in view the safety of the persons in the theatre.

Wherever theatre regulations are enacted, the compliance with them should not be left to the voluntary choice of theatre owners or managers, but should be made compulsory. The Municipal Building Department of every city should have the fullest possible power to examine the plans for all contemplated theatres, and also the plans of alterations intended to be made in existing theatres. These should either be altered to meet the requirements such as are outlined in these pages, or else they should be closed by the authorities.

It has been well said that "the problem of building a safe theatre is one where a combination of architectural and engineering talent is required. Each specialist, to solve his special problems, must take the technical resources of our age into account, and bring them to bear on the question."

No other class of buildings bears so much evidence of the modern tendency to specialization. For the successful planning and designing of a modern theatre building the architect should have associated with him a number of specialists or experts. The architect himself prepares the plan of the building and the design. He should have the general superintendence of the entire work, and should consult with and direct the other experts, so that a harmonious working together, so necessary to avoid clashes or mistakes, will result. The architect should also have charge of the interior arrangements and equipment, and he should plan in particular the decorative schemes of the auditorium, the ceiling, the proscenium-boxes, the foyers and vestibules, the entrances and façades; the seating-arrangements, the lighting, the sight lines, the acoustics, etc.

The services of the constructing engineer are required in difficult foundations, in the iron construction, the roof construction, and for the design and details of the iron fire-

curtain (where this is used). A heating and ventilating engineer should design and superintend the heating system, the steam-boiler and the power plant, and the engines for running the exhaust-fans or blowers for the ventilation of the theatre. A hydraulic engineer will have charge of the water-supply system for house use as well as for fire protection; he will lay out the automatic-sprinkler system, provide the fire-pump, the fire-hydrants, and fire-valves, and possibly the hydraulic presses for the stage machinery. A sanitary expert will design and carry out the entire drainage system of the building and the plumbing arrangements; he should lay out the arrangement of the public and other toilet-rooms, and in general look after the ventilation and sanitation in the theatre. A gas expert will specify and plan the gas service and lighting system, the details of the stage gas-table, and provide the gaslight fixtures. An electrical expert will have under him the entire electric plant, the dynamos, switches, wiring and lighting system, the fixtures, and possibly the electric stage machinery. A chemist, finally, will provide and advise on the fire-proof treatment of the woodwork on the stage, on the chemical impregnation of the canvas decorations and scenery, the draperies, stage furniture, and of the costumes.

The higher conception of the function of

the stage is that it should be educational in character, that it should form a moral and intellectual recreation for the people. A theatre ought to be a place where one goes to find motives for ideal thinking and where one's thoughts are elevated above the realm of the commonplace every-day happenings. A great deal of real enjoyment may be derived from a good theatre performance, for many matters combine to make a play at once attractive and educating, such as the music and the sound and modulation of the human voice heard in declamation or in song; the idealized stage figures clad in picturesque or historically correct costumes; the ever-varying stage-settings, which attract and please the eye; the rich blending of the colors; the brilliant illumination of the stage sceneries; all forming a rare combination of attractions in the field of the fine arts,— painting, sculpture, architecture, poetry, music, and rhythmic motion.

But, in order to derive real enjoyment and pleasure from a stage performance, certain requirements for the audience must necessarily be fulfilled. Of these, the most important one, beside which all others dwindle into comparative insignificance, is that the audience must feel safe and secure beyond all doubt from the dangers of fire, smoke, and panic, and that the players must be made equally safe.

II.

COMFORT AND SANITATION.

BUILDINGS for the representation of theatrical plays, when made safe against danger from fire and panic, must fulfil two other essential conditions; viz., they must be rendered comfortable as well as healthful.

Under the requirements of *comfort* are included the conditions that all spectators are well and conveniently seated, without being crowded, also that every seat in each division of the auditorium offers a good sight, and that the acoustics in all parts of the house are perfect. The other requirement, of *healthfulness*, embraces the following conditions: plenty of pure air, freedom from draughts, moderate warming in winter, suitable cooling in summer; freedom at all times from dust, bad odors, and disease-germs. In addition to the foregoing requirements relating to the theatre audience, due regard should be paid to the comfort, healthfulness, and safety of the performers, the stage-hands, and mechanics, who, as a rule, are required to spend more hours in the stage part of the building than the playgoers, who are

seated in the auditorium only during a performance. In the following pages the chief sanitary improvements required for theatre buildings will be briefly discussed.

UNSANITARY CONDITION OF THEATRES.

It is no exaggeration to state that in the majority of theatre buildings disgraceful unsanitary conditions prevail. This is especially true of the older existing buildings, in which sanitation in general, and ventilation in particular, are sadly neglected. The air of many theatres during a performance becomes overheated and stuffy, pre-eminently so in those theatres where illumination is still effected by means of gas-lights. At the end of a long performance the air is often almost unbearably foul, causing headache, slight nausea, or dizziness.

In ill-ventilated theatres a chilly air often blows into the auditorium from the stage when the curtain is raised. This air movement is the cause of colds to many persons in the audience, and it is otherwise objectionable, for it carries with it noxious odors from the stage or understage, and in gas-lighted theatres the air is laden with products of combustion from the footlights and other means of stage illumination.

In many such buildings an attempt at ventilation is made, by utilizing the heat due to

the numerous flames of the central chandelier over the auditorium to create an ascending draft and thereby cause a removal of the contaminated air; but seldom is provision made for the introduction of fresh air from outdoors, hence the scheme of ventilation always results in failure. In other theatre buildings some openings for introduction of pure air are provided under the seats or in the floor, but these are often found stuffed up with paper, because the audience suffered from draughts. The fear of draughts in a theatre also leads to the closing of the few possibly available outside windows, and for this, as well as other reasons, the doors leading to the exit corridors are invariably kept shut. The plan of a theatre building renders it impossible, in all but rare instances, to provide outside windows, and therefore "air flushing" during the day cannot be practised. In the case of the older theatres, which are located in the midst or rear of other buildings, the nature of the site precludes a good and efficient arrangement of the main intakes or ducts for the fresh air which is to be supplied to the auditorium.

But lack of ventilation is not the only sanitary defect of theatre buildings. We find in such buildings quite a number of other sources of air pollution. In the parts devoted to the audience there are carpeted floors, which become saturated with dirt and dust carried in by

the playgoers, to which are often added the expectorations of careless or untidy persons, which in a mixed theatre audience are ever present. The dust likewise adheres to the furniture, to the plush seats, the hangings and decorations, and intermingled with this dust are numerous minute floating organisms and doubtless some germs of disease.

Then again, we find behind the curtain other sources of air contamination, a general lack of cleanliness and disgraceful conditions, such as untidy actors' toilet-rooms, ill-drained cellars, defective sewerage, leaky drains, foul water-closets, overcrowded and poorly located dressing-rooms, into which no fresh air ever enters. The stage floor is often covered with dust, which is stirred up by the frequent scene-shifting or by the dancing of performers, and much of which is absorbed and retained by the canvas scenery.

Under such conditions the state of health of both theatregoers and performers is bound to suffer. Many persons can testify from personal experience to the ill-effects incurred by spending a few hours in a crowded and unventilated theatre. Yet the very fact that the stay in such buildings is a brief one seems to render most people indifferent, and complaints are seldom uttered. It really rests with the theatregoing public to enforce the much-needed improvements. As long as they will

flock to a theatre on account of some attractive play or "star actor," disregarding entirely the unsanitary condition of the building, so long will the present notoriously bad conditions remain. When the public does not call for reforms, theatre managers and owners of playhouses will not, as a rule, trouble themselves about the matter. What we need, what we have a right to demand, is theatre buildings which have less outward and inside gorgeousness, but in which the paramount subjects of comfort, safety, and health are diligently studied and generously provided for. Let the general public but once show a determined preference for sanitary conditions and surroundings in theatres and abandon visits to ill-kept theatres and I venture to predict that the necessary reforms in sanitation will soon be introduced, at least in the better class of playhouses. In the cheaper theatres, the concert and amusement halls, the houses with "continuous" shows, the variety theatres, sanitation is perhaps even more urgently required, and may be readily enforced by a few visits and peremptory orders from the Health Board.

When, in 1898, the writer, in a paper on "Theatre Sanitation" presented at the annual meeting of the American Public Health Association, stated that "chemical analyses show the air in the dress circle and gallery of many a theatre to be in the evening more foul than

the air of street sewers," the statement was received by some of his critics with incredulity. Yet the fact is true of many theatres. In chemical analyses of air the amount of carbonic acid is usually taken as an indication of the existing contamination, and it is assumed that the organic vapors are in direct proportion to the amount of carbonic acid, not including in the latter the CO_2 due to the products of illumination. We know that normal outdoor air contains from 0.03 to 0.04 parts of CO_2 per 100 parts of air, or from 3 to 4 parts per 10,000.

From a report by Dr. H. Endemann, Ph.D., on the "Chemical Examination of the Air of Various Public Buildings," contained in the Third Annual Report of the Board of Health of the City of New York, dated April 30, 1873, the following notes are taken relative to the air contamination in some of the New York theatres at a time when electric lighting had not yet been introduced: —

In examining the air of theatres and public halls, it is to be taken into consideration that in these cases we have two sources for the carbonic acid in the air, the one being respiration, the other the combustion of illuminating-gas. The latter item, on examination, proves to be of immense importance.

In some special cases the proportion was approximately determined with the aid of the theatre statistics, giving the number of persons present in the theatre on the particular evening when the examination was made, and the amount of gas consumed per hour. It was thus ascertained that, in one theatre with slim attendance, the proportion of carbonic

acid formed by respiration to that formed by combustion of gas was one to seven.

In another theatre, with a full house, the proportion was found to be one to four and one-half, and even in the most crowded and poorest illuminated theatres the proportion would not become less than one to two, so that even under the least favorable circumstances but one-third of all the carbonic acid found could be due to respiration. Taking it for granted that the dangerous properties of a vitiated atmosphere grow more in proportion to the organic vapor present than with the carbonic acid alone, the importance of this consideration becomes at once evident.

The following tabulated statement gives the results obtained: —

DATE.	TIME.	THEATRE OR HALL.	PART OF HOUSE.	CO_2.*	NO. IN AUDIENCE.
March 27,	9.00 P.M.	Tony Pastor,	Gallery,	37.1	f. h.†
"	9.30	"	Parterre,	28.8	"
"	9.50	Atlantic Garden,	"	18.75	"
March 29,	8.45 P.M.	Stadt Theatre,	Gallery,	19.1	s. a.
"	8.53	"	Parterre,	27.7	"
"	9.00	Bowery Theatre,	Gallery,	36.5	c. h.
"	9.05	"	Parterre,	23.2	"
March 31,	9.35 P.M.	Union Sq. Theatre,	Gallery,	28.9	m. f.
"	9.00	Cooper Institute, (large hall)	Parterre,	27.0	"
"	9.20	Germania Theatre,	"	26.0	f. h.
April 4,	8.30 P.M.	Niblo's Garden,	Balcony,	33.9	f. h.
"	9.15	Wallack's Theatre,	Gallery,	36.5	"
April 9,	9.15 P.M.	Booth's Theatre,	Balcony,	10.6	m. f.
"	8.15	Olympic Theatre,	"	20.0	f. h.
"	8.45	Fifth Ave. Theatre,	Gallery,	40.6	"
"	8.45	"	Parterre,	14.2	"
April 11,	8.30 P.M.	Athenæum,	Parterre,	13.0	f. h.
"	9.00	Bryant's Theatre,	"	17.0	"
"	9.15	Grand Opera House,	"	11.8	s. a.
"	9.25	"	Balcony,	23.7	"

* In 10,000 parts of air.

† Explanation of abbreviations: f. h., full house; s. a., slim attendance; c. h., crowded house; m. f., moderately full.

The provisions made for heating and ventilating these places are about the same in all cases. Registers in the parquet supply the fresh warm air, which, ascending, escapes by a large circular opening in the centre of the ceiling, where, for the purpose of creating a stronger current, a large candelabrum is placed.

There are, however, besides the register air, other currents of fresh air perceptible, especially if the outflow of waste air is larger than the supply obtainable from the register. One of these currents comes from the stage; another may, in many theatres, be noticed in the upper gallery, especially if windows are opened to enhance ventilation. This latter is a downward current, and is in many cases so effective that the air in the gallery may even be better than the air in the parterre.

The high temperature obtained by the combustion of the illuminating-gas at once excludes the idea of the reversion of the natural current, by extracting the waste air from below.

To meet the tendency of the warm register air to at once leave the building on the shortest way, without mixing with the vitiated air of the building, to any extent, a provision is made in two of our New York theatres which deserves imitation. These two theatres are the Union Square and Booth's Theatre. A "fan," driven by a steam-engine, forces the air into a "chamber" beneath the floor of the parquet, whence it is discharged through numerous holes in the risers of the platforms on which the chairs rest. By thus subdividing the fresh register air, before discharging it into the interior of the building, diffusion is made more perfect.

The results of the examination of air, as given above, show at once the beneficial effect of this arrangement.

A few chemical analyses of the air in Eng-

lish theatres,* quoted below, suffice to prove how large the contamination sometimes is:—

Strand Theatre,	10.00 P.M.,	Gallery,	.101†
Surrey Theatre,	"	Boxes,	.111
"	12.00	"	.218
Olympia Theatre,	11.30	"	.082
"	11.55	"	.101
Victoria Theatre,	10.00	"	.126
Haymarket Theatre,	11.30	Dress Circle,	.076
City of London Theatre,	11.15	Pit,	.252
Standard Theatre,	11.00	"	.320
Theatre Royal, Manchester,		"	.273
Grand Theatre, Leeds,		"	.150
" "		Upper Circle,	.143
" "		Balcony,	.142
Prince's Theatre, Manchester,			.110–.170

Compare with these figures the following analyses of the air of sewers. Dr. Russell, of Glasgow, found the air of a well-ventilated and well-flushed sewer to contain 0.051 vols. of CO_2. The late Prof. W. Ripley Nichols, of the Massachusetts Institute of Technology, conducted many careful experiments on the amount of carbonic acid in the Boston sewers, and found the following averages; viz., 0.087, 0.082, 0.115, 0.107, 0.08, or much less than the above analyses of theatre air showed. He states: "It appears from these examinations that the air, even in a tide-locked sewer, does

* These analyses were made by Drs. Smith, Bernays, and de Chaumont.
† Parts of CO_2 per 100.

not differ from the standard as much as many, no doubt, suppose."

The few examples selected show conclusively the need of ample ventilation for theatres. The fact that a large part of the carbonic acid found in the air of theatres towards the end of the performance is due to the products of combustion of gaslights does not alter the case, for the necessity of a plentiful supply of fresh air to large audience-halls exists, possibly just because of it.

A comparison of the number of bacteria found in a cubic foot of air inside of a theatre and in the air of a street sewer would form a more convincing statement. I have been unable to find any such records of bacteriological tests made in theatres. But, according to *London Engineering*, Professors Carnelley and Haldane, of University College, Dundee, who carried out bacteriological investigations on the air of schoolhouses and that of sewers, state that they found the number of micro-organisms in sewer air less than in outside air. "The air of sewers was better than the air of naturally ventilated schools, while even mechanically ventilated schools were more polluted with organic matter. The sewer air contained a much smaller number of micro-organisms than the air of houses. . . . The micro-organisms in sewer air come entirely, or

nearly so, from outside, and are not derived, or only so in relatively small numbers, from the sewer itself. The average number of micro-organisms in sewer air was less than in outside air; namely, as 8.9 to 15.9."

In a similar way, an examination of the air in the sewers under the Houses of Parliament, London, showed that the number of micro-organisms was considerably less than that in the outside air.

While, therefore, the air of sewers is, contrary to expectation, remarkably free from germs, the indoor air of crowded assembly-halls, laden with floating dust, is particularly rich in living micro-organisms derived from walls, furniture, floors, and floor-coverings. This has been proven by Tyndall, Miquel, Frankland, and other scientists.

In recent years marked improvements in theatre planning and equipment have been effected, and corresponding steps in advance have been made in matters relating to theatre hygiene. It should, therefore, be understood that my remarks are intended to apply to the average theatre, and in particular to the older buildings of this class. There are, in the large cities, a few well-ventilated and hygienically improved theatres and opera-houses, in which all requirements of sanitation are observed. Later on, when speaking more in detail of

theatre ventilation, instances of well-ventilated theatres will be mentioned. These, nevertheless, are exceptional, and the need of urgent and radical measures for comfort and health in the majority of theatres is obvious. Much is being done in our enlightened age to improve the sanitary condition of school buildings, jails and prisons, hospitals, and dwelling-houses. Why, I ask, should not our theatres receive some consideration?

VENTILATION OF THEATRE BUILDINGS.

The efficient ventilation of a theatre building is conceded to be an unusually difficult problem. Some of the reasons for the difficulties are the following: first of all, the auditorium of a fair-sized theatre, and much more so that of a large opera-house, holds a vast number of people, for whom a sufficient volume of pure air must be provided. In winter-time this air must be tempered or warmed, and it is next to impossible to meet the different views as to the proper temperature. Some persons feel the slightest movement of air as a draught; others again object to the heat and complain of a feeling of suffocation. Another serious difficulty arises from the fact that a theatre building comprises several equally important, but essentially different, parts, such as the audience-hall, the stage, the foyers, corridors, and stairs, and these parts are at times brought

together, as for instance when the curtain rises, or when a part of the spectators go out during the intervals between acts. The stage is sometimes crowded with hundreds of performers and at other times it is nearly empty; there may be sudden changes in the temperature of the external air, or the barometric and hygrometric conditions, the direction and force of the wind, may change. It is difficult always to be prepared for such contingencies. A further embarrassment lies in the fact that the ventilation, whatever the system may be, must not interfere with the acoustics of the auditorium. Until the recent introduction of the incandescent electric light much difficulty was also due to the great number of lights, to the row of footlights, to the large chandelier.

The principal sources of air contamination in a theatre are the carbonic acid eliminated in the process of breathing by thousands of spectators; the organic vapors, moisture, and odors thrown off by respiration and perspiration of the same persons, many of whom doubtless have not in their homes proper facilities for thorough ablutions; the odors due to damp or unclean clothing and underclothing; the products of gas-illumination; the smells arising from neighboring stables or restaurant kitchens; the sewer emanations due to defective soil or waste pipes, to untrapped or disused floor-drains, and to ill-flushed and ill-kept

water-closets and urinals; the noxious fumes and smoke due to colored fires, gunshots, etc., on the stage; lastly, the dust and dirt floating in the air, or brought in from outside by the boots and skirts of men and women, which attaches itself readily to carpets, hangings, and upholstery.

To this variously polluted air is due the often apparent drowsiness of audiences, the throat troubles and general bad state of health of actors and singers, and the headache which many persons experience on the morning following a visit to a theatre. But, cannot all this be remedied, so as to render playgoing a real pleasure to the public?

In order to ventilate a theatre properly, the causes of noxious odors arising from bad plumbing or defective drainage should be removed; outside fumes or vapors must not be permitted to enter the building either through doors or windows, or through the fresh-air duct of the heating-apparatus. The substitution of electric lights in place of gas is a great help towards securing pure air. All this being accomplished, a standard of purity of the air should be maintained by proper ventilation. The popular notion of a well-ventilated theatre is that in warm weather the hall is kept cool, and in cold weather moderately warm, without any regard as to whether the same air is breathed over and over. Ventilation in-

cludes both the removal of the vitiated air and the introduction of pure air from outdoors, and the consequent entire change of the air of a hall three or four times per hour. The fresh air brought into the building must be ample in volume; it should be free from contamination, dust, and germs (particularly pathogenic microbes), and with this in view it must be first purified in cities by filtering, spraying, or washing. It should be warmed in cold weather by passing over hot-water or steam-pipe stacks, and cooled in warm weather by means of ice or the brine of mechanical refrigerating-machines. The air should be of a proper degree of humidity, and what is most important of all, it should be admitted into the various parts of the theatre imperceptibly, so as not to cause the sensation of draught; in other words, its velocity at the inlets must be very low. The fresh air should enter the audience-hall at numerous points, so well and evenly distributed that the air will be equally diffused throughout the entire horizontal cross-section of the hall. The air indoors should have as nearly as possible the composition of air outdoors, an increase of the CO_2 from 0.3 to 0.6 being the permissible limit. The vitiated air should be continuously removed by mechanical means, taking care, however, not to remove a larger volume of air than is introduced from outdoors. The conditions

enumerated, while not unattainable in practice, constitute the chief reason why the problem of theatre ventilation is beset with difficulties.

Regarding the amount of fresh outdoor air to be supplied to keep the inside atmosphere at anything like standard purity, authorities differ somewhat, the theoretical amount being three thousand cubic feet per person per hour (fifty cubic feet per minute). This amount is required in the section on theatres of the Boston Building Law. In Austria, the law calls for 1,050 cubic feet per hour per person, and stipulates that there should be an interval of 2½ hours between matinée and evening performances, so that the air may be thoroughly changed in the meanwhile. The regulations of the Prussian Minister of Public Works call for seven hundred cubic feet of air per person per hour. Professor von Pettenkofer suggests an air-supply from 1,410 to 1,675 cubic feet per hour (twenty-three to twenty-eight cubic feet per minute), while General Arthur Morin calls for twelve hundred to fifteen hundred cubic feet per hour, and Dr. John S. Billings, an American authority on heating and ventilation, requires thirty cubic feet per minute, or eighteen hundred cubic feet per hour. In the Vienna Opera House, which is described as one of the best-ventilated theatres in the world, the air-supply is fifteen cubic feet per person per minute. The Madison Square

Theatre in New York is stated to have an air-supply of twenty-five cubic feet per person. In a moderately large theatre seating twelve hundred persons, the total hourly quantity of air to be supplied would according to above requirements amount to from 1,440,000 to 2,160,000 cubic feet. It is not an easy matter to arrange the fresh-air conduits of a size sufficient to furnish this volume of air; it is obviously costly to warm such a large quantity of air, and it is a still more difficult problem to introduce it without creating objectionable currents, and finally, inasmuch as this air cannot enter the auditorium unless a like amount of vitiated air is removed, the problem must include the provision of artificial means for the removal of large volumes of air.

Where gas-illumination is used, each gas-flame requires an air-supply per hour of from one hundred and forty to two hundred and eighty cubic feet, according to General Morin, in addition to that furnished to each person. In Boston the Building Law requires "fifty cubic feet of air per minute for each light other than an electric light for each occupant."

Many writers on ventilation subdivide assembly-halls into those in which the floor and galleries are occupied during many hours continuously, and those which are only occupied a few hours each day, and class the theatres among the latter buildings. This discrimina-

tion has, in my judgment, far less force than appears at first sight, and should hardly be taken as an argument in favor of a lesser standard volume of air-supply, particularly when it is remembered that in many theatres there are not only evening, but also afternoon, performances, not to mention possible rehearsals in the morning, and again there are quite a number of playhouses where the nowadays popular "continuous" performances draw large crowds from early afternoon until nearly midnight.

A slight consideration of the volumes of air which must be supplied and removed in a theatre to secure a complete change of air three or four times an hour demonstrates the impossibility of securing satisfactory results by the so-called natural method of ventilation, i. e., the removal of air by means of flues with currents due either to the aspirating force of the wind, or due to an artificially increased temperature in the flues. In other words, it becomes necessary to adopt mechanical means of ventilation by using either exhaust-fans, or pressure-blowers, or both, these being driven either by steam-engines or by electric motors. In the older theatres, which were lighted by gas, the heat of the flames could be utilized, to a certain extent, in creating ascending currents in the outlet shafts, and this accomplished some air-renewal. But nowadays the central

chandelier is almost entirely dispensed with; glowing carbon lamps fed by electric currents replace the gas-flames, hence mechanical ventilation seems all the more indicated.

MODERN SYSTEMS OF THEATRE VENTILATION.

Several methods may be adopted for the introduction of the fresh air and for the removal of the vitiated air. Owing to the planning and arrangement of theatres it is not feasible to follow the well-known and practically successful method adopted for ventilating a school-room or a large room in a dwelling. Experience has shown that, for winter ventilation, the best results are attained in schools by introducing the air by flues located in an inside wall, high above the floor, or close to the ceiling, and by removing the foul air near the floor through registers placed in the same wall. The warm pure air thus introduced rises to the ceiling of the apartment, along which it spreads out evenly to become cooled by the chilling influence of the outside walls and windows. It then descends gradually along these and is drawn across the room to the outlet flue near the floor. The auditorium of a theatre presents different conditions, for it has no outside walls, being surrounded by foyers, corridors, staircases, and it has also very few, if any, outside windows. It is at once apparent that the fresh air to be supplied and the foul

air to be removed cannot be made to enter and escape at the same part of the enclosed space: it follows that the fresh-air and the foul-air ducts must open at points nearly opposite to each other.

Two principal methods of theatre ventilation may be arranged: in one of these the fresh air enters at or near the floor, and rises upwards to the ceiling to be removed by suitable outlet flues; in this method the incoming air follows the naturally existing air-currents; in the other method, pure air enters at the top through perforated cornices or holes in the ceiling and gradually descends to be removed by outlets located at or near the floor line. The two systems are known as the "upward" and the "downward" systems; each of them has been successfully tried, each offers some advantages, and each has its advocates. In both systems a separate supply of fresh air to the boxes, balconies, and galleries is required, which may be accomplished in various ways. Owing to the different opinions held by architects and engineers, the two systems have often been made the subject of inquiry by scientific and Government Commissions in France, England, Germany, and the United States.

A French scientist, Darcet, was the first to suggest a scientific system of theatre ventilation. He made use of the heat from the central chandelier for removing the foul air, and admitted the pure air through numerous openings in the

floor and through inlets in front of the boxes, but the audience stopped up the holes in the floor on account of the resulting draught, and in consequence of this the exhaust ventilation at the ceiling drew air from the stage.

Dr. Reid, an English specialist in ventilation, is generally regarded as the originator of the upward method in ventilation. He applied the same with some success to the ventilation of the Houses of Parliament in London. Here fresh air is drawn in from high towers and is conducted to the basement, where it is sprayed and moistened. A part of the air is warmed by hot-water coils in a sub-basement, while part remains cold. The warm and the cold air are mixed in special mixing-chambers. From here the tempered air goes to a chamber located directly under the floor of the auditorium and passes into the hall at the floor level through numerous small holes in the floor. The air enters with low velocity, and to prevent unpleasant draughts the floor is covered in one hall with hair carpet, and in the other with coarse hemp matting, both of which are cleaned every day. The removal of the foul air takes place at the ceiling and is assisted by the heat from the gas-flames.

The French engineer, Péclet, an authority on heating and ventilation, suggested a similar system of upward ventilation, the fresh air being admitted near the floor through registers or openings in the sides or risers of the steppings; the foul air is removed at the ceiling through perforated and hollow cornices, but instead of allowing it to pass out through the roof, he conducts the foul air downward in an underground channel which has exhaust-draught. Trélat, another French engineer, followed practically the same method.

A large number of theatres are ventilated on the upward system; of these I will make mention first of the large Vienna Opera House, the ventilation of which was planned by Dr. Boehm. The auditorium holds about three thousand persons, and a fresh-air supply of about fifteen cubic feet per minute, or from nine hundred to one thousand cubic feet

per hour, per person is provided. The fresh air is taken in from the gardens surrounding the theatre and is conducted into the cellar, where it passes through a water spray which removes the dust and cools the air in summer. A suction-fan ten feet in diameter is provided, which blows the air through a conduit, forty-five square feet in area, into a series of three chambers located vertically over each other under the auditorium. The lowest of these chambers is the cold-air chamber; the middle one is the heating-chamber and contains steam-heating stacks; the highest chamber is the mixing-chamber. The air goes partly to the heating and partly to the mixing chamber; from this it enters the auditorium at the rate of one foot per second velocity through openings in the risers of the seats in the parquet, and also through vertical wall-channels to the boxes and upper galleries. The total area of the fresh-air openings is seven hundred and fifty square feet. The foul air ascends, assisted by the heat of the central chandelier, and is collected into a large exhaust-tube. The foul air from the gallery passes out through separate channels. In the roof over the auditorium there is a fan which expels the entire foul air. Telegraphic thermometers are placed in all parts of the house and communicate with the inspection-room, where the engineer in charge of the ventilation controls and regulates the temperature.

The Vienna Hofburg Theatre was ventilated on the same system.

The new Frankfort Opera House has a ventilation system modeled upon that of the Vienna Opera House, but with improvements in some details. The dressing-rooms and other rooms for the stage personnel are ventilated separately by direct-indirect radiators under the windows, and each dressing-room has an outlet-flue with two registers for summer and winter ventilation respectively. The passages, staircases, and the auditorium are heated by indirect radiation. The house has a capacity of two thousand people, and for each person fourteen hundred cubic feet of fresh air

per hour are supplied. A fan about ten feet in diameter and making ninety to one hundred revolutions per minute brings in the fresh air from outdoors and drives it into chambers under the auditorium arranged very much like those at Vienna. The total quantity of fresh air supplied per hour is 2,800,000 cubic feet. The air enters the auditorium through gratings fixed above the floor level in the risers. The foul air is removed by outlets in the ceilings, which unite into a large vertical shaft below the cupola. An exhaust-chamber over the sun-burner in the ceiling of the auditorium contains heated tubes to rarify the air and to cause an ascending current. An exhaust-fan of ten feet diameter is placed in the cupola shaft and is used for summer ventilation only. Every single box and stall is ventilated separately. The cost of the entire system was about $125,000; it requires a staff of two engineers, six assistant engineers, and a number of stokers.

Among well-ventilated American Theatres the Madison Square Theatre (now Hoyt's) is a well-known example. Here the fresh air is taken down through a large vertical shaft on the side of the stage. There is a seven-foot suction-fan in the basement which drives the air into a number of boxes with steam-heating stacks, from which smaller pipes lead to openings under each row of seats. The foul air escapes through openings in the ceiling and under the galleries. A fresh-air supply of fifteen hundred cubic feet per hour, or twenty-five cubic feet per minute, per person is provided.

The Metropolitan Opera House is ventilated on the plenum system and has an upward movement of air, the total air-supply being seventy thousand cubic feet per hour.

In the Academy of Music, Baltimore, the fresh air is admitted mainly from the stage, and the exits of foul air are in the ceiling of the auditorium.

Other theatres ventilated by the upward method are the Dresden Royal Theatre, the Lessing Theatre in Berlin, the Opera House in Buda-Pesth, the new theatre in Prague,

the new Municipal Theatre at Halle, and the Criterion Theatre in London.

The French engineer, Gen. Arthur Morin, is known as the principal advocate of the downward method of ventilation. This was at that time a radical departure from existing methods because it apparently conflicted with the well-known fact that heated air naturally rises. Much the same system was advocated by Dr. Tripier in a pamphlet published in 1864,* and quite a spirited discussion arose between him and General Morin as to whom belonged the credit of suggesting the plan first. The earlier practical applications of this system to several French theatres did not prove as much of a success as anticipated, and the plan advocated by Morin was subsequently abandoned, the failure being due probably to the existing gas-illumination and the central chandelier, and also to the absence of mechanical means for inducing a downward movement of the air.

In 1861 a French Commission, of which General Morin was a member, studied the problem of theatre-ventilation and proposed the reversing of the currents of air by admitting the fresh air at both sides of the stage-opening high up in the auditorium, and also through hollow floor-channels for the balconies and boxes; in the gallery the openings for fresh air were located in the risers of the steppings. In the parquet the air was exhausted by numerous openings under the seats. This ventilating system was carried out at the Théâtre Lyrique, the Théâtre du Cirque, and the Théâtre de la Gaieté.

Dr. Tripier ventilated a theatre in 1858 with good success on a similar plan, but he introduced the air partly at the rear of the stage and partly in the tympanum in the auditorium. He removed the foul air at the floor level and separately in the rear of the boxes. He also exhausted the foul air from the upper galleries by special flues heated by the gas chandelier.

* Dr. A. Tripier, Assainissement des Théâtres, Ventilation, Éclairage et Chauffage.

The Grand Amphi-Theatre of the Conservatory of Arts and Industries, in Paris, was ventilated by General Morin on the "downward" system. The openings in the ceiling for the admission of fresh air aggregated one hundred and twenty square feet, and the air entered with a velocity of only eighteen inches per second. The total air-supply per hour was six hundred and thirty thousand cubic feet. The foul air was exhausted by openings in steps around the vertical walls, and the velocity of the outgoing air was about two and one-half feet per second.

The introduction of the electric light in place of gas gave a fresh impetus to the downward method of ventilation, and modern mechanical appliances have also helped to dispel the former difficulties in securing a positive downward movement.

The Chicago Auditorium is ventilated on this system, a part of the air entering from the rear of the stage, the other part from the ceiling of the auditorium downward. This plan coincides with the proposition made in 1846 by Morrill Wyman, though he admits that it cannot be considered the most desirable method.

A good example of the downward method is given in the New York Music Hall, opened in May, 1891. This hall is used for musical entertainments only and has neither drop-curtain nor footlights. The main hall has a seating-capacity of three thousand persons and standing-room for one thousand more. Fresh air at any temperature desired is made to enter through perforations in or near the ceilings, the outlets being concealed by the decorations; it passes out through exhaust-registers near the floor line, under the seats, through perforated risers in the terraced steps. About ten million cubic feet of air are supplied per hour, and the velocity of influx and efflux is one foot per second. The air supplied per person per hour is figured at twenty-seven hundred cubic feet. The total cubic space of the hall is about two million cubic feet, and the air is changed from four and one-half to five times per hour. The fresh air is taken

in through a shaft at roof level and having seventy square feet area. The air is heated by steam-coils arranged in sections, and it is cooled in summer by ice on racks. The mechanical plant comprises four blowers, six and seven feet diameter, and three exhaust-fans, each of six feet diameter.

The downward method of ventilation was suggested in 1884 for the improvement of the ventilation of the Senate Chamber and the Chamber of the House of Representatives in the Capitol at Washington, but the system was not adopted by the Board of Engineers appointed to inquire into the method.

The downward method is also used in the Hall of the Trocadéro, Paris, in the old and also the new buildings for the German Parliament, Berlin, in the Chamber of Deputies, Paris, and others.

Professor Fischer, a modern German authority on heating and ventilation, in a discussion of the relative advantages of both methods reaches the conclusion that both are practical and can be made to work successfully, but that for those audience-halls which are lighted by gaslights the upward method is preferable.

In arranging for the removal of foul air it is necessary, particularly in the downward system, to provide separate exhaust-flues for the galleries and balconies, the registers of which are usually placed near the floor level in the rear walls.

Unless this is provided for, the exhaled air for the occupants of the higher tiers would mingle with the descending current of pure air supplied to the occupants of the main audi-

torium floor. But in the upward system, too, it seems best to draw the foul air off at the ceiling level of each tier, particularly at the gallery, where the air is usually the most contaminated.

Mention should also be made of a proposition originating recently in Berlin to make the roof of auditoriums domelike by dividing it in the middle, so that it can be partly opened like the roof of an astronomical observatory by means of electric or hydraulic machinery; such a system would permit of keeping the ceiling open in summer-time, and would render the theatre not only airy, but also free from the danger of smoke. A system based on similar principles is in actual use at the Madison Square Garden in New York, where part of the roof consists of sliding skylights, which can be made to open or close during the performance.

From the point of view of safety in case of fire, which, as we have seen, in a theatre usually breaks out on the stage, it is without doubt best to have the air-currents travel from the auditorium in a direction towards the stage roof. This has been successfully arranged in some of the later Vienna theatres. From the point of view of good acoustics, it is on the other hand better, as already mentioned, to have the air-currents travel from the stage towards the auditorium. Obviously,

therefore, it is a somewhat difficult problem to reconcile the conflicting requirements of safety from smoke and fire-gases, good acoustics, and perfect ventilation.

DETAILS OF VENTILATING SYSTEMS.

In this short essay, details of theatre ventilating systems must of necessity be omitted, but a few points may receive brief mention. The best position of the intake of the fresh air from outdoors depends primarily upon the site of a theatre. In the Continental theatres of Europe, which are usually isolated, the inlet shaft can be placed in a shaded corner of the grounds or parkways which surround the theatre; in this case the inlet need not be kept higher than six or seven feet above the street level, but it should be raised to avoid drawing exhalations from the soil, and it should also be protected against dust when located near a street. In the American and English theatres, on the other hand, which do not enjoy the advantages of a free site, the air must be taken from one of the sides of the buildings. Inasmuch as the air of theatre courts is generally stagnant and impure, and at times subject to pollution from neighboring buildings, or from nuisances committed therein, it is advisable to take the fresh air in at a higher elevation by means of special towers or shafts. It should be remarked, though, that in cities it is advisable

not to make the inlet shafts too high, for above forty or fifty feet in elevation the air of our cities is impure from soot, smoke, acid and sulphurous and other exhalations from chimneys, domestic fireplaces, heating-furnaces and steam-boilers of industrial establishments, also from other floating impurities, and sewer-air passing out from the soil and vent pipe extensions on roofs. It is also necessary to locate the inlet of the fresh-air shaft as far away as possible from the vent shaft which removes the foul air from the theatre. The fresh-air shaft should be covered on top as a protection against rain, snow, or wind.

It is likewise necessary, in the case of theatres located in a city block, to purify the air before admitting it to the warming-chamber. This is accomplished by providing large chambers wherein the incoming air loses its velocity of ingress and thus permits the dust to settle; the air is often filtered by means of screens of cheese-cloth or cotton or woolen fabrics placed in a zigzag fashion near the fresh-air inlet to these conduits. These and air-filters of fine-meshed wire sieves should be frequently looked after and cleaned. Air is also purified by passing it through fine films or sprays of pure water. Means are sometimes provided for moistening the air, when too dry, or for tempering it before it enters the larger heating-chambers, to avoid condensation in the cool

underground conduits or chambers. In the best modern arrangements only a part of the fresh-air supply is warmed, while the other part passes directly to the mixing-chambers or conduits, where it is suitably mixed with the warm air, before it enters the auditorium. In summer-time the fresh air supplied to theatres is cooled, either by being made to pass over racks containing large cakes of ice, or by artificial refrigeration, the latter system being the more successful of the two.

Concerning the inlets for fresh air in the auditorium, the chief desideratum is that the air should enter at a slow velocity in order not to be felt as a draught. The colder the incoming air is the less should be its velocity. A velocity of one to one and one-half feet per second is considered by authorities as the best. This is essential particularly where the air is introduced near the floor level. The combined area of the inlets must therefore be very large. Take the above-named example of a medium-sized theatre, seating twelve hundred persons; here we found the minimum air-supply required to be 1,440,000 cubic feet per hour, or twenty-four thousand cubic feet per minute. With a velocity not exceeding one hundred feet per minute this would require an area of two hundred and forty square feet for the inlets. In order to diffuse the air evenly there should be numerous registers either in

the floor, or, better, in the risers of the steps for the rows of chairs. Floor registers become receptacles for dust and hence are objectionable. Sometimes deflecting pieces are fastened at the inlets to avoid the sensation of cold draught to the feet. In this respect the downward method of ventilation offers unquestionable advantages, for near the main ceiling it is possible to introduce the air at a somewhat higher velocity. Moreover, exhausting the foul air at the floor has the incidental advantage of keeping the feet of persons warm.

Taking the above amount of air-supply as a fair estimate, it will be seen that the fresh-air intakes as well as the main conduits for air in the cellar require to be of formidable dimensions, and this is of course equally true of the conduits for the extraction of the vitiated air. Mention has already been made of the necessity of supplying fresh air separately and directly to the occupants of the boxes, and to the spectators seated in the balcony and gallery.

The removal of the vitiated air, if same is accomplished near the ceiling, may be accomplished with a velocity as high as six to eight feet per second.

Ventilation of a theatre, however accomplished, should not interfere with the good acoustics of the auditorium. Some claim that the currents of air should be from the stage

towards the auditorium, and propose even to introduce a part of the fresh air on the stage. This would not always prove efficient, particularly during the sometimes long intervals following the lowering of the proscenium curtain. In the downward method of ventilation the principle may be followed by admitting the air in the two corners of the auditorium about ten feet above the proscenium-arch, the so-called "tympanum."

The stage of a theatre requires to be well ventilated, for often it becomes filled with smoke or gases due to firing of guns, colored lights, torches, representations of battles, etc. There should be in the roof over the stage large outlet flues, or sliding skylights, controlled from the stage, for the removal of the smoke. These, in case of an outbreak of fire on the stage, become of vital importance in preventing the smoke and fire-gases from being drawn into the auditorium and suffocating the persons in the gallery seats.

Where gas-lighting is still used on the stage, it is important to provide a separate downward ventilation for the footlights. This, I believe, was first successfully tried at the large Scala Theatre of Milan, Italy.

The actors' and supers' dressing-rooms, which are often overcrowded, require efficient ventilation, and other parts of the building, like the foyers and the toilet, retiring, and

smoking rooms, must not be overlooked. Regarding ventilation of toilet-rooms one point is very important, which also applies to smoking-rooms; namely, that where fresh air is introduced by pressure-blowers (plenum system) these rooms should have a lesser air-supply in order to maintain a constant movement of air from the foyers or auditorium towards the rooms. In the case of ventilation by aspiration (vacuum method), on the contrary, the same rooms should have a stronger suction towards their outlet flues to prevent local odors or smoke from passing into corridors or foyers. All rooms with intense gas, candle, or oil-lamp illumination must have provision made for the removal at the ceiling of air vitiated by products of combustion.

METHODS OF HEATING.

The entrance-halls, vestibules, lobbies, staircases, and corridors do not need so much ventilation, but should be kept warm to prevent annoying draughts. They are usually heated by abundantly large direct steam or hot-water radiators, whereas the auditorium and foyers, and often the stage, are heated by indirect radiation. It would lead too far to consider the various methods of heating as applied to theatres in detail. Inasmuch as it is very desirable, for the sake of safety from fire, to have but one source of heat, the heating is

usually done by means of one large central steam or hot-water apparatus. The new Police and Building Regulations of Berlin require one central heating-system for the stage and the auditorium, and the heating-chamber must be enclosed with solid brick walls. All ducts or conduits for hot air, pipes and coils for steam, etc., must be surrounded with non-conducting material. Owing to the fact that during a performance the temperature in the auditorium is quickly raised by contact of the warm fresh air with the bodies of persons (and by the numerous lights, where gas is used), the temperature of the incoming air should be only moderate. In the best modern theatre heating-plants it is usual to gradually reduce the temperature of the air as it issues from the mixing-chambers towards the end of the performance. Both the temperature and the hygrometric conditions of the air should be controlled by an efficient staff of intelligent heating engineers.

In the larger theatre buildings the practical management of the heating and ventilating apparatus cannot and should not be entrusted to the ordinary grade of firemen. Economical results are best attained, as far as is consistent with comfort, good ventilation, and sanitation by placing the entire plant in charge of an organized corps of efficient engineers and trained assistants.

LIGHTING.

But little need be said regarding theatre lighting. Twice during the present century have the system and methods been changed. In the early part of the present century theatres were still lighted with tallow candles or with oil-lamps. Next came what was at the time considered a wonderful improvement; namely, the introduction of gas-lighting. The generation who can remember witnessing a theatre performance by candle or lamp lights, and who experienced the excitement created when the first theatre was lit up by gas, will soon have passed away. Scarcely twenty years ago the electric light was introduced, and there are to-day very few theatres which do not make use of this improved illuminant. The advantages of the electric light are threefold; viz., it renders theatres much safer against the danger from fire, provided the wiring is properly insulated; it generates much less heat than gas-light; and finally, it secures better air in theatres and vastly simplifies the problem of ventilation, as I have already shown. By the electric lighting the noxious products of combustion, incident to all other methods of illumination, are eliminated: no carbonic-acid gas is generated to render the air of audience-halls irrespirable, and no oxygen to support com-

bustion is drawn from the air introduced for breathing.

The incandescent electric light was introduced almost simultaneously into theatres in England, Germany, and in the United States, and the results have everywhere exceeded the expectations of the most sanguine. It being now an established fact that the electric light increases the safety of human life in theatres and other places of amusement, its use is in many city or building ordinances made imperative — at least on the stage and in the main body of the auditorium. Stairs, corridors, entrances, etc., may, as a matter of precaution, be lighted by a different system, by means of either gas or auxiliary vegetable-oil or candle lamps, protected by glass enclosures against smoke or draught, and provided with special inlet and outlet flues for air.

FLOORS AND FLOOR-COVERINGS.

Passing to other desirable internal improvements of theatres, I would mention first the floors of the auditorium. Usually they consist of wooden boards laid on sleepers, and covered with heavy carpets. Sometimes a solid or fire-proof construction is adopted, in which case the filling-in material requires to be free from organic matters. The covering of the floor by carpets is objectionable — in theatres more so even than in dwelling-houses. Night

after night the carpet comes in contact with thousands of feet, which necessarily bring in a good deal of street dirt and dust. The latter falls on the carpets and adheres to them, and as it is not feasible to take the carpets up except during the summer closing, a vast accumulation of dirt and organic matter results, some of the dirt falling through the crevices between the floor boards. Many theatregoers are not tidy in their habits regarding expectoration, and as there must be in every large audience some persons afflicted with tuberculosis, the danger is ever-present of the germs of the disease drying on the carpet and becoming again detached by the friction of the shoes or of ladies' skirts. These germs may therefore become stirred up and float in the air which we are obliged to breathe in a theatre.

As a remedy I would propose abolishing carpets entirely and using instead some of the modern available floor-coverings, such as linoleum, thin polished parquetry oak floors, varnished floors of hard wood, painted and stained floors, interlocked rubber-tile floors, cork floors, and, at least for the aisles, encaustic or mosaic tiling, or terrazzo floors. Between the rows of seats, as well as in the aisles, long rugs or mattings may be laid down loose, for these can be taken up without much trouble. They should be frequently shaken, beaten, and cleaned.

WALLS AND CEILINGS.

Regarding the walls, ceilings, and cornices, the surfaces should be of a material which can be readily cleaned and is non-absorbent. In halls, staircases, and gangways, marble wainscotting forms an excellent sanitary wall finish; walls in toilet-rooms should be tiled. Stucco finish is unobjectionable, but should be kept flat, so as not to offer dust-catching projections. Oil-painting of the larger wall-surfaces in an auditorium is preferable to a covering with rough wall-papers, which hold large quantities of dust. The so-called "sanitary" or varnished wall-papers have a smooth, non-absorbent, easily cleaned surface and are therefore unobjectionable. All heavy decorations, draperies, and hangings in the boxes and plush covers for railings are to be avoided.

FURNITURE.

The theatre furniture should likewise be of a material which does not catch or hold dust. The usual upholstered plush-covered chairs and seats retain a large amount of it and are not readily cleaned. Leather-covered or other sanitary furniture, or rattan seats, would constitute a great improvement. The comfort of theatre-goers would be much increased if more generous space for seats were allowed: seats to be comfortable should have a width of twenty or twenty-one inches, and the distance between

adjoining rows should be from thirty-two to thirty-three inches. Overcrowding in the auditorium should not be permitted, and to guard against it it would be well to enforce the rule that no more tickets should be sold than the theatre license permits.

ACTORS' DRESSING-ROOMS.

Overcrowding is likewise objectionable in the stage building; the minor actors' dressing-rooms in particular should not be subject to it. We often find four or five actors placed in one small, overheated, unventilated dressing-room, located in the basement of the building, without outside windows, and fitted with three or four gas-jets, for actors require a good light in "making up." More attention should be paid to the comfort and health of the players; more space and a better location should be given to their rooms. A theatre should have a sufficient number of dressing-rooms to provide for the sometimes numerous players of spectacular dramas. Every dressing-room should have a window to the outer air, and also a special ventilating-flue. Properly trapped wash-basins should be fitted up in each room. There should be sufficient and separate, well-ventilated water-closet and urinal accommodation for the artists of both sexes. In the dressing-rooms and in the corridors and stairs leading from them to the stage all draughts must be

avoided, as the performers often become overheated from the excitement of the acting, and dancers in particular often leave the stage bathed in perspiration. Sanitation, ventilation, and cleanliness are quite as necessary for this part of the stage building as for the auditorium and foyers.

The following interesting quotation from an article in the *Forum* by Mr. Rudolph de Cordova, an actor of much experience, is taken from Mr. Philip Hubert, Jr.'s, recent book, "The Stage as a Career," and serves to illustrate the usual condition of actors' dressing-rooms and of their surroundings in theatres:—

> The janitor (local manager) has an important bearing on the actor's condition, which finds its expression in his playing, and possibly in his nervous organization. He supplies the house, and in most cases furnishes quarters for the actors, such as no self-respecting slave-owner would in the old days have condemned a slave to occupy. For the public nothing is too good: fine silken draperies hang in the boxes; soft, comfortable chairs are in the auditorium, which is as handsome and harmoniously decorated as the architect's scheme and the owner's purse will allow. For the actor anything is good enough. Instead of silken draperies he finds only a tattered curtain at the window, if, indeed, he finds a curtain at all, or even a window which it might cover. Instead of soft, comfortable chairs, one wooden chair, none too clean, or a chair minus a back, will be the only seat, and not infrequently, if he wishes to sit down, he must do so on the edge of his trunk. Instead of delicately tinted walls, he will find dirty walls which have not been treated

even to a coat of whitewash for years. While in the auditorium a soft carpet covers the floor, in the actor's room a carpet rarely exists, or if by chance there be something which was once a carpet, it is so dirty that it would be better away. The washing-appliances of the actor's room usually consist of a small basin with a tap of running water. Most people would expect that, as the winter is the theatrical season, and the paints used by the actors are made of grease, hot water would be at hand. But this is rarely the case, and in many instances running water in the dressing-room is unknown. It is not uncommon for actors to refrain from using the basins, preferring to remove the "make-up" as well as possible with vaseline and to wait until the hotel is reached to complete this part of the toilet. Tin basins and buckets are not the worst that I have seen "on the road," for once the water was in dirty, battered old lard-tins, and basins had to be bought by our manager.

It is seldom that the actor other than the star or leading man gets a room to himself, frequently having to share these discomforts with several members of the company. The room may be under the stage, or in the "flies," or even higher. In either case the lack of ventilation is appalling, the heat under the stage being exceeded only by the heat above it, and it is a wonder that actors do not die by the score of throat and lung complaints induced by draughts in an overheated atmosphere. The stage door invariably opens directly on the street, permitting blasts of cold air to sweep through the regions behind the curtain. The dressing-rooms are often damp, and I have dressed with three other gentlemen in a theatre in one of the large cities where we had to step across a pool of water in the middle of the room.

But before entrance to the dressing-room can be gained, the stage door must be passed. The imposing front of the theatre and its brilliant lights are for the public's use and gaze, and the idea that anything is good enough for the actor

is carried out in the stage entrance. If it happens to be in a street instead of an alley-way — and alleys are always dirty — it is almost certain that the door will be up or down a narrow flight of steps, at the bottom of which there is invariably in wet weather a pool of water. The stage itself may or may not be clean. I remember once in Chicago noticing that the stage of one of the chief theatres was, to put it delicately, somewhat soiled, and I asked one of the men how often it was washed. "Oh, we never get time to wash it," he replied. "You see, we have Sunday-night performances and we are always using it, so that we can only sweep it." Such is the condition behind the scenes as noted within my own observation. Will any honest-minded man say that it is not a degradation to be condemned to occupy such rooms? Is there any one, outside the dramatic profession, who would care to subject a fellow-being to these conditions, especially a fellow-being through the exercise of whose abilities he makes his living, and whose work depends greatly on the proper use of the emotional faculties, which are largely influenced by surroundings? It is not much that the actor asks. He never thinks of anything approaching luxury in the theatre, but he does ask — he has a right to demand — cleanliness. For the disgraceful condition of the theatres the janitor, of course, is primarily responsible, but he has an accessory in crime in the person of the manager of the company, of the star, and even in the actors themselves. If half a dozen of the leading "stars" and managers were to combine and inform a janitor that they would not play in his house unless the dressing-rooms were put into proper repair and order, clean quarters would replace the present squalor and dirt. Or if the manager and the "star," when the contract for the engagement was made, put in a clause insisting on the dressing-rooms being neat and clean, and finding them otherwise, refused to allow the company to act and gave the reasons, public opinion would unquestionably insist on the theatre being made decent.

Moreover, the protest would be an advertisement — the dearest object to the managerial heart — which could not be easily overestimated. The "star" does not trouble himself about the comfort of the actor because his mind is fully occupied and his own comfort is pretty well looked after. The best room in the theatre is usually known as the "star's;" his name is even printed on the door, as if there were a possibility of its being mistaken. Besides being larger than the rest, it is nearly always on the stage floor; it is furnished with some pretensions to comfort; the floor is covered with a carpet; it has light; there are washing-appliances. For these reasons and because nearly every "star" thinks himself altogether on a different plane from the actors in his support, intercourse between him and them is not intimate, and he does not hear of their discomforts and degradations — at least until they are past remedying.

DRAINAGE AND PLUMBING.

It will suffice to mention that defects in the drainage and sewerage of a theatre building must be avoided. Dampness in the cellar part of the building must be looked upon as a serious fault. When deep pits, required in the understage for the machinery and traps, cannot be drained on account of insufficient depth of the street sewer, artificial drainage by well-known special devices is necessary, or the entire pit, bottom and sides, must be rendered absolutely waterproof.

Space forbids also to discuss the important subject of plumbing. The well-known requirements of house drainage should be observed

in theatres as much as in other public buildings. Suitable well-appointed and well-kept toilet-rooms must be provided for the public as well as for the stage personnel.*

WATER-SUPPLY.

The proper arrangement of the water-supply of a theatre requires much thought and study, for a large volume of water flowing under a suitable pressure is needed, not only for the plumbing fixtures, for washing and scrubbing, for the steam-boilers, but also for fire-extinguishing purposes.† Where the management of a theatre looks out for the comfort of the audience by distributing between the acts trays with tumblers holding cooled drinking-water, attention should be paid to the purity of the ice used in cooling, and for well-known reasons water-coolers should be used in which the melted ice does not mix with the water. If filtered water is supplied, the filters require almost daily attention and cleaning.

REMOVAL OF REFUSE.

The removal of ashes, litter, sweepings, oily waste, and other refuse should be attended to

* The reader will find the subject discussed and illustrated in the author's work "Sanitary Engineering of Buildings," Vol. I., 1899, and also in his paper "Theatre Sanitation," in the Transactions of the American Public Health Association, for 1898.

† See the author's work "Theatre Fires and Panics, Their Causes and Prevention," 1895.

with promptness and regularity. This should be included in the general sanitation or maintenance of cleanliness in a theatre. It is only by constant attention to properly carried out cleaning methods that such a building for the public can be kept in a proper sanitary condition. Floating air impurities, like dust and dirt, carried in with muddy shoes or skirts cannot be removed or rendered innocuous by the most perfect ventilating scheme. Mingled with the dust floating in the auditorium or lodging in the stage scenery are numbers of exceedingly minute bacteria or germs. Among the pathogenic germs will be those of tuberculosis, contained in the sputum discharged in coughing or expectorating. When this dries on the carpeted floor, the germs become readily detached, mingle with the dust, are inhaled by the playgoers, and thus become a prolific source of danger in all public assembly-halls, and in particular in theatres which, owing to their plan, cannot have any successful "air-flushing." It is for this reason, principally, that the processes of cleaning, sweeping, and dusting should, in a theatre, be under intelligent management. On the same ground I have emphasized the objections to the usual floor-coverings, upholstery, decorations, and theatre furniture.

CLEANING, DUSTING, AND SWEEPING.

To guard against the ever-present danger of infection by germs, the sanitary floor-coverings recommended should be wiped every day with a moist rag or cloth. Carpeted floors should be covered with moist tea-leaves or sawdust before sweeping, to prevent the usual dust-raising. The common use of the feather duster is to be deprecated, for it only raises and scatters the dust, but it does not remove it; on the contrary, the dust settles again in the still air. Dusting of the furniture should be done with a dampened dust-cloth. This work should be done in a systematic and exacting manner, if good results are to be accomplished. The cleaning should include the hot-air registers, where a large amount of dust collects. This can only be removed by occasionally opening up the register-faces and wiping out the pipe surfaces. Attention should also be paid in cleaning to the baseboards and to all cornice projections on which dust constantly settles. During the dusting and sweeping the windows should be kept open; an occasional admission of sunlight, where practicable, would likewise be of the greatest benefit.

PERIODICAL SANITARY INSPECTIONS.

The writer believes that a sanitary inspection of all theatre buildings should be insti-

tuted once a year, when they are closed up in summer. He would also suggest that the granting of the annual license should be made dependent not only, as at present, upon the condition of safety of the building against fire and panic, but also upon its sanitary condition. In connection with the sanitary inspection a thorough disinfection by sulphur, or, better, with formaldehyde gas, should be carried out by the health authorities. If necessary, the disinfection of the building should be repeated several times a year, particularly during general epidemics of influenza or pneumonia.

The safety measures against outbreaks of fire, dangers from panics, accidents, etc., discussed in the first part of this essay, are, in a certain sense, also to be considered as sanitary improvements.*

In order to anticipate captious criticisms, the writer would state that in these pages he has not attempted to set forth new theories, nor to advocate any special system of theatre ventilation. His aim was to describe existing defects and then to point out well-known remedies. The question of efficient theatre sanitation belongs quite as much to the province of the sanitary engineer as to the architect. It

* See also the author's work "Theatre Fires and Panics," 1895.

is one of paramount importance, certainly more so than the purely architectural features of exterior and interior decoration.

It remains for the theatregoing public to demand, and for the theatre owners and lessees to carry out, the measures so urgently needed for the better safety, comfort, and sanitation of these places of amusement.

Index.

Works by the Same Author.

Sanitary Engineering of Buildings.

Vol. I. First edition, 1899. Price, $5.00. 454 pages, 103 illustrations, and 6 plates.

CONTENTS: Defective Plumbing and Sewer-Gas. — Traps and Systems of Trapping. — Sewerage of Buildings. — Plumbing Fixtures. — Sewage Removal and Sewage Disposal. — Leading Principles of House Drainage and Sanitary Plumbing. — Improved Methods of House Drainage. — Proper Arrangement of Water-closet and Bath Apartments. — A Plea for Sanitation in Factories and Workshops. — The Sanitary Drainage of Tenement-Houses. — On Testing House Drains and Plumbing Work. — Simplified Plumbing Methods.

CONTENTS OF VOL. II. (*in preparation*): Domestic Sanitary Appliances. — Domestic Water Supply. — External and Internal Sanitary Arrangements for Suburban and Country Houses. — The Sewage Question for Villages and Isolated Country Houses. — The Plumbing, Water Supply, and Sewerage of Hospitals. — Theatre Sanitation. — The Sanitary Features of Markets and Abattoirs. — Kitchen, Laundry, and Drying-Room Arrangements. — School Sanitation. — Bathing and Different Forms of Baths. — The Modern Rain-Bath. — Spray-Baths for Insane Patients and for Public Schools. — Sanitary House Inspection.

Sanitary Questions.

A chapter on the water supply, drainage, sewerage, heating, and other sanitary questions relating to country houses. Supplement to "Cottages; or, Hints on Economical Building." New York, 1884. Price, $1.00.

House Drainage and Sanitary Plumbing.

New York: Seventh edition, 1898. 6 plates, illustrations. Price, 50 cents.

Recent Practice in the Sanitary Drainage of Buildings,

with Memoranda on the Cost of Plumbing Work. New York: Second edition, 1890. Price, 50 cents.

The Disposal of Household Wastes.

A discussion of the best methods of treatment of the sewage of farm-houses, isolated country houses, suburban dwellings, houses in villages and smaller towns, and of larger institutions, such as hospitals, asylums, hotels, prisons, colleges, etc., and of the modes of removal and disposal of garbage, ashes, and other solid house refuse. Illustrated. 1890. Price, 50 cents.

Gas Lighting and Gas Fitting.

Including specifications and rules for gas-piping, notes on the advantages of gas for cooking and heating, and useful hints for gas consumers. Second edition, rewritten and enlarged, 1890. Price, 50 cents.

A Guide to Sanitary House Inspection,

or, Hints and Helps Regarding the Choice of a Healthful Home in City or Country. New York: Third edition, 1895. Price, $1.00.

The Prevention of Fire.

The author's suggestions on fire prevention and fire protection, although written chiefly with reference to hospitals, lunatic asylums, and orphans' homes, are equally applicable to hotels, warehouses, factories, mills, schools, churches, dwelling-houses, and public buildings of all kinds. Second edition, 1887. Price, 60 cents.

Theatre Fires and Panics; Their Causes and Prevention.

New York, 1896. Price, $1.50.

Anlagen von Haus-Entwaesserungen, nach Studien Amerikanischer Verhältnisse.

Berlin, 1880. 5 plates of illustrations. Price, 80 cents.

Die Hauskanalisation.—Prinzipien und Praktische Winke für eine rationelle Anlage von Haus-Entwaesserungen. Eine bau-hygienische Skizze.

Leipzig, 1885. Price, 60 cents.

Entwaesserungs-Anlagen Amerikanischer Gebäude.

Heft 10 der "Fortschritte der Architektur." Stuttgart, 1897. 441 illustrations and 2 plates. Price, $6.00.

Sanitary Engineering.

1898. Price, post-paid, $1.25.

CONTENTS: Architecture and Engineering.—Definition of Civil Engineering.—Engineering Specialties.—Definition of Sanitary Engineering.—Course of Study in Sanitary Engineering.—Actual Practice of the Sanitary Engineer: Water Supply of Cities and Dwellings, Sewerage, Prevention of Pollution of Water-Courses, Sewage Disposal, Street Pavements, Street Cleaning, Removal of Ice and Snow, Street Sprinkling, Cleansing Footways and Sidewalks, Removal of Refuse, Garbage Disposal, Scavenging, The Laying-Out of Cities and Towns, Sanitation of Towns, Sanitary Engineering in Relation to Habitations, Railway and Ship Sanitation, Sanitary Inspection of Buildings and Building-Sites, The Sanitary Engineer's Services as Expert in the Courts, Sanitary Engineering in Case of Epidemics, in Time of War, and in Sudden Calamities in Civic Life.—The Title "Sanitary Engineer."—General Qualifications of the Sanitary Engineer.—The Sanitary Engineer in Public Life and Municipal Government.—APPENDIX: Work of the Sanitary Engineer in Case of Sudden Outbreaks of Epidemics, Work of the Sanitary Engineer in Time of War, Work of the Sanitary Engineer after Sudden Calamities, Catastrophes, and Great Disasters in Civic Life.